Locomotive Stokers

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TYPE D DUPLEX STOKER
DUPONT SIMPLEX STOKERS

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NOTE.—This book is made up of separate parts, or sections, as indicated by their titles, and the page numbers of each usually begin with 1. In this list of contents the titles of the parts are given in the order in which they appear in the book, and under each title is a full synopsis of the subjects treated.

TYPE D DUPLEX STOKER

DUPONT SIMPLEX STOKERS

TYPE D DUPLEX STOKER

Serial 4000 Edition 1

DESCRIPTION AND OPERATION

INTRODUCTION

1. Reason for Development.—A locomotive stoker is a steam-driven device that carries the coal from the tender and delivers it to the back of the firebox. From this point the coal is usually distributed over the fire by means of steam jets. The firing of the coal is accomplished without any labor on the part of the fireman, with the exception of the work necessary for the proper operation of the stoker. Mechanical stokers were developed on account of the fact that locomotives have become so large that it was impossible to fire them to their full capacity by hand. The capacity of a fireman to fire coal is approximately equal to 5,000 pounds of coal per hour, while the largest Mallet compound locomotives when worked to the limit have a coal consumption of 12,000 pounds per hour.

A locomotive stoker is not only a labor-saving device, but it also makes it possible for heavier trains to be moved at higher speeds.

PRINCIPLES OF OPERATION

2. Conventional Arrangement.—The description and operation of the Duplex stoker will be more readily understood if an explanation of the principle on which the stoker oper-

ates is first given. Fig. 1 is a conventional arrangement which will serve to illustrate the principle of operation of Type D Duplex stoker. When the stoker is in operation, the piston rod a of the engine moves back and forth. A rack a_1 with

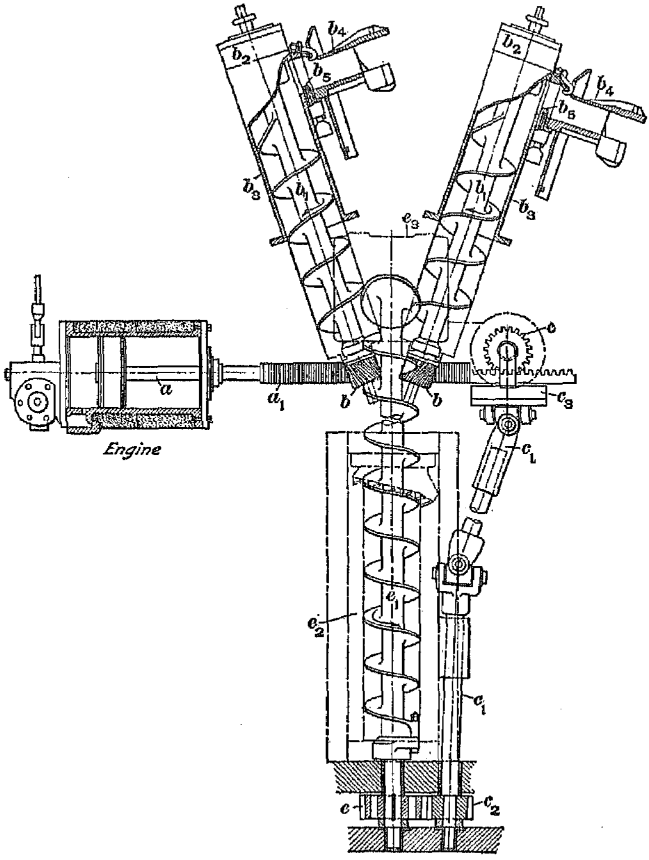

FIG. 1

teeth cut in the top and front sides is connected to the outer end of the piston rod and moves with the piston. A gear b is connected to the lower end of each of the elevating screws b_1, and these gears mesh with the vertical teeth in the front side of the rack a_1. The gear c on the front end of the shaft c_1

meshes with the teeth in the top of the rack, and the gear c_2 on the back end of the shaft meshes with the gear e on the back end of the conveyer screw e_1. The coal lies in the trough e_2, in the bottom of which is the conveyer screw. When the piston a moves outwards, the rack a_1, on account of the fact that the teeth engage with the gears b and c, will impart a turning movement to the elevator screws b_1 and the shafts c_1. The shafts c_1 turn the gear c_2, which turns the gear e and, therefore, the conveyer screw e_1. On the inward stroke of the piston a and the rack a_1, the arrangement of the mechanism in the interior of the parts c_3 and b_2 is such as to prevent any movement from being imparted to the conveyer screw and the elevating screws; that is, these screws stop turning on the inward stroke of the piston and turn only on the outward stroke. The turning movement of the conveyer screw forces the coal in the conveyer trough e_2 into the hopper e_3, where it is caught by the elevator screws b_1, and carried upwards. The coal falls from the casings b_3, which surround the elevator screws, into the distributer tubes b_4, which are set in openings in the back boiler head. Steam from the jet nozzles b_5 blows the coal into the firebox. The shape of the distributer tubes b_4 is such as to deflect the coal and distribute it evenly over the fire.

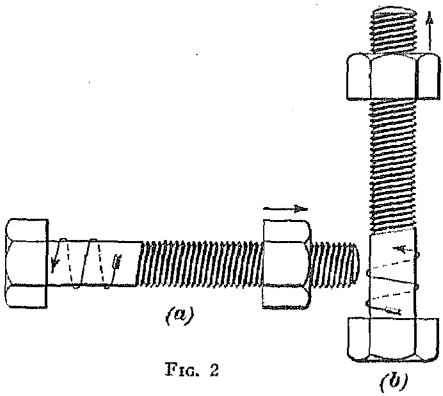

FIG. 2

3. Movement of Coal by Screws.—The following explanation will make the conveying and elevating of coal by screws e_1 and b_1, Fig. 1, more easily understood. The conveyer screw e_1 is called a left-hand screw because the thread of the screw slopes upwards to the left. The elevating screws b_1 are called right-hand screws, because the thread slopes upwards to the right.

When a left-hand screw, like the conveyer screw, is turned to the right, as shown by the arrow, the coal will be moved forwards. A right-hand screw, like the elevating screw b_1, when turned to the left, or in the direction of the arrow, will carry the coal upwards. Turning the conveyer screw to the right will bring a higher or more advanced part of the thread continually in contact with the coal, which is accordingly pulled forwards. The same reasoning applies to the elevator screws, which, when turned to the left, bring a higher part of the thread in contact with the coal, which therefore moves upwards.

The conveyer screw can be compared to the bolt with the left-hand thread shown in Fig. 2 (*a*), and the nut can be compared to the coal. If the nut is prevented from turning and the bolt is turned in the direction shown, the nut will move ahead. In (*b*) the nut will move upwards, and this bolt can be compared to the elevator screw because it has a right-hand thread.

GENERAL ARRANGEMENT AND OPERATION OF STOKER

4. Views of Stoker.—In Fig. 3 is shown the Duplex stoker as seen from the right side. Fig. 4 shows the stoker as seen from the front, Fig. 5 (*a*) is a view of the stoker in the cab, and (*b*) is a side view of the stoker with some of the parts shown in section. Fig. 5 (*a*) shows more especially the steam-pipe arrangement to the stoker and the various globe valves which are used when the stoker is being operated.

5. Principal Parts of Stoker.—Type D Duplex stoker, Fig. 3, consists of three principal parts or systems: the conveying and crushing system *A*, which is carried on the tender; an elevating system *B*, and a distributing system *C* on the locomotive. The parts of the conveyer and elevating systems which convey and elevate the coal are driven by the steam engine *a*.

6. Arrangement of Parts.—Reference will be made to Figs. 3, 4, and 5 (*b*) when the arrangement of the parts of the

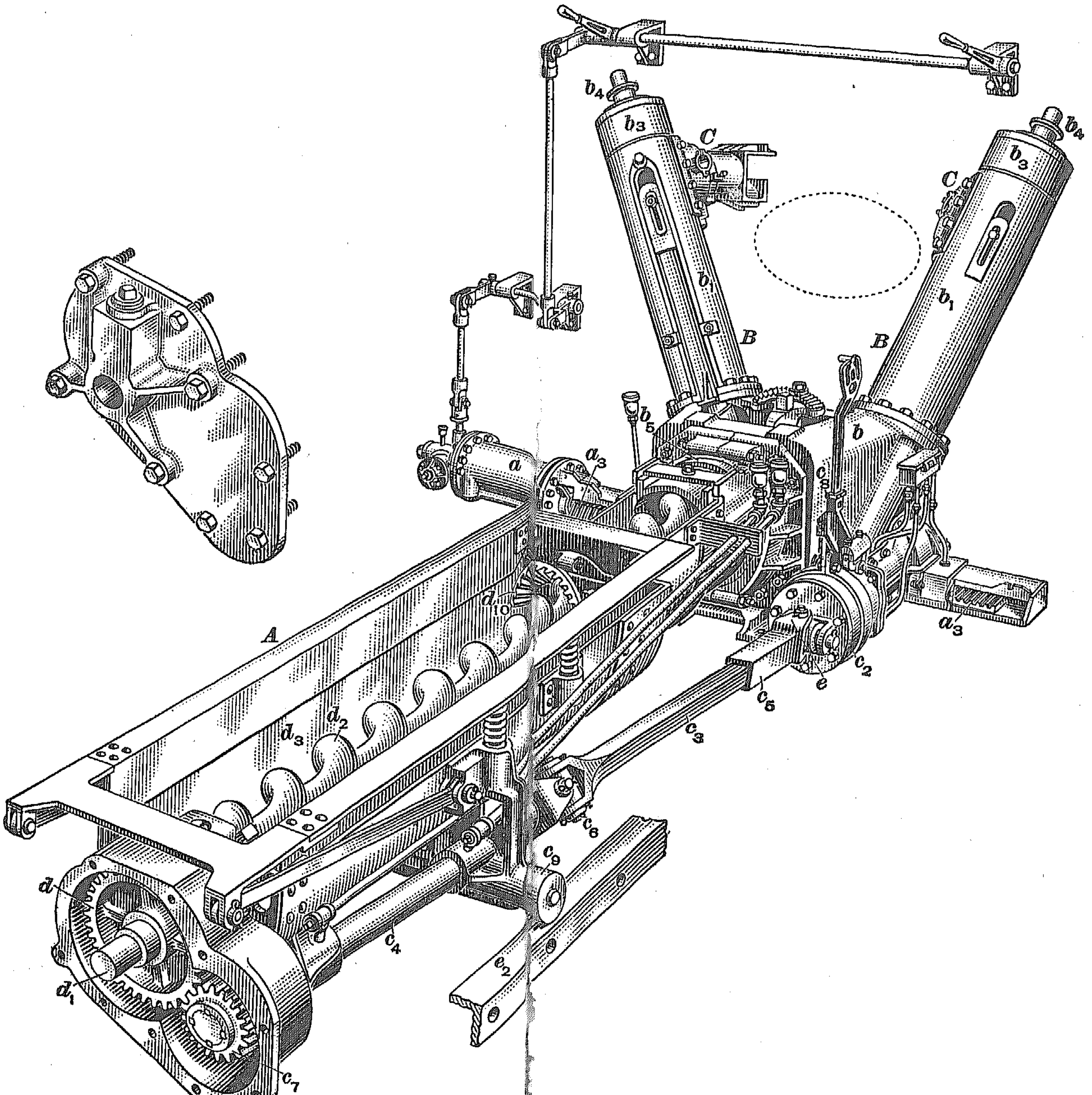

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FIG. 3

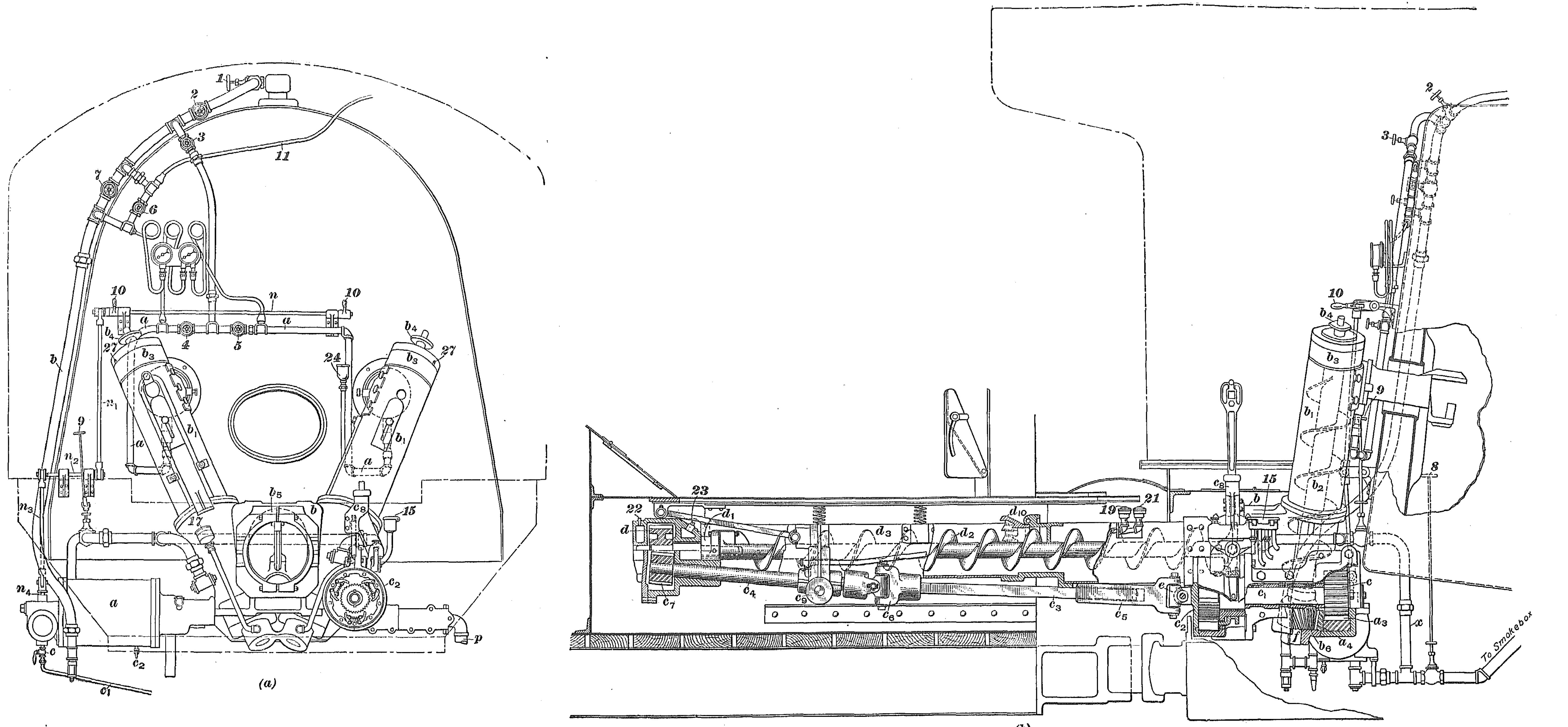

Fig. 5

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stoker is explained. The cylinder of the steam engine a, Fig. 4, is bolted to the rack housing a_1 and the housing is secured to the transfer hopper b by the bolts and nuts a_2. The rack housing encloses a rack a_3, Fig. 3, the left end of which is connected to the piston rod of the steam engine a. Gear c, Fig. 5 (b), which meshes with the teeth in the top of the rack a_3, is placed on the shaft c_1. The gear and the shaft turn the conveyer drive and reverse c_2, and the two shafts c_3

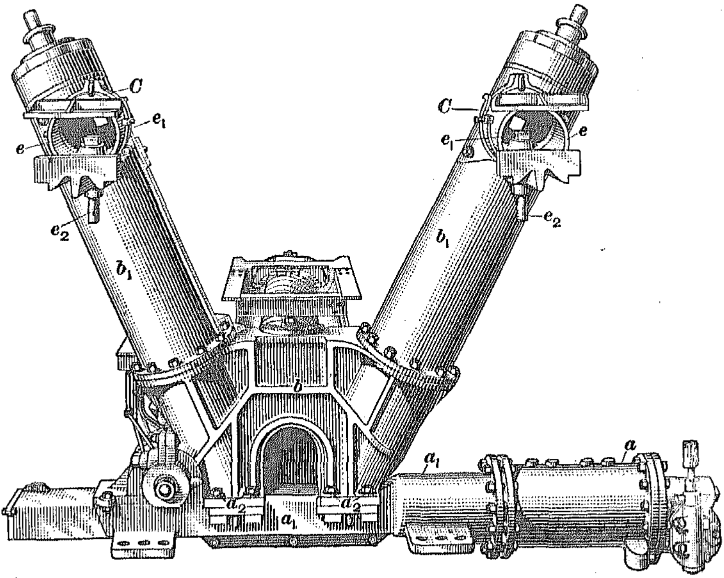


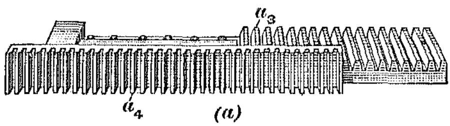
FIG. 4

and c_4. The elevator casings b_1, Fig. 3, are bolted to the transfer hopper b and form housings for the upper parts of the elevator screws b_2, Fig. 5 (b). The lower parts of the screws extend down into the transfer hopper. The lower ends of the screw shafts f turn in bearings in the transfer hopper, and a gear b_6 is placed on the shaft of each screw. These gears mesh with the teeth a_4 in the side of the rack a_3.

In Fig. 6 (a) is shown the driving rack a_3, and in (b) is shown the driving-rack housing within which the driving rack slides. The false cylinder head shown connected to the left end of

the housing is secured to and forms a cover for the cylinder of the driving engine. The driving rack is a steel forging and consists of two connected parts, the main rack a_3 and the rack a_4. The teeth in the rack a_3 drive the conveyer drive and reverse c_2, Fig. 5 (*b*), through the gear c and the shaft c_1, and the teeth in the rack a_4 drive the two elevator-shaft gears b_6.

7. The conveyer drive and reverse c_2, Figs. 3 and 5 (*b*), which is driven by the rack a_3, has a flexible connection sleeve



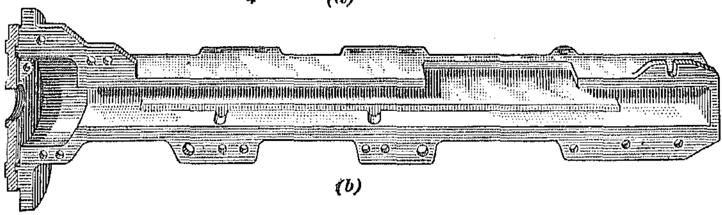


FIG. 6

c_5 connected to it by a universal joint e. The end of the conveyer flexible connection shaft c_3 fits loosely in a square hole in the end of the flexible connection sleeve c_5. The shaft c_3 is connected by a universal joint at c_6 to the gear-shaft c_4, on the end of which is keyed and pressed a gear c_7, which meshes with the gear d on the end of the conveyer-screw shaft d_1. The shaft d_1 is bolted to the conveyer screw d_2, which is placed in the bottom of the conveyer trough d_3. The outer end of the screw extends to an opening in the back end of the transfer hopper b.

The conveyer screw then receives its movement from the rack a_3, Fig. 5 (*b*), the gear c, the shaft c_1, the conveyer drive and reverse c_2, the conveyer flexible connection shaft c_3, the gear shaft c_4, the gears c_7 and d, and the gear-shaft d_1.

The mechanism of the conveyer drive and reverse c_2, Fig. 3, and the elevator drive and reverse b_3 on the upper ends of

the elevator casings b_1 is such that a turning movement is transmitted to the conveyer and elevator screws on the outward stroke only of the rack a_3. On the inward stroke of the rack, the screws do not turn, because, if the arrangement were such that they did, the coal would be moved away from the firebox instead of toward it. The elevator drive and reverse is provided with a reverse lever c_8, by means of which the conveyer screw may be reversed in case it becomes clogged, or the screw may be stopped. The reverse lever is moved by a bar that fits into a socket in the lever, the bar being removed when not in use. Pawl shifters b_4 on the top of the elevator drive and reverse b_3 are provided to reverse or stop the movement of either one of the elevator screws.

DISTRIBUTION OF COAL

8. **General Description.**—The part of the stoker which distributes the coal is shown at *C*, Fig. 4. It consists primarily of distributer tubes *e*, which are secured to the elevator casings b_1, and jet nozzles e_1. The jet nozzles, to which the lower ends of steam pipes e_2 are connected, are set in the distributer tubes. These tubes extend through openings cut in the back boiler head and serve as a firing plate over which the coal, after it leaves the elevator screws, is blown by jets of steam from the jet nozzles into the firebox. The distributer tubes are so constructed that the coal is scattered evenly over all parts of the fire.

BALL AND UNIVERSAL JOINTS

9. **Description.**—On account of the uneven movement of the locomotive and the tender, it is necessary to provide suitable connections between the part of the stoker on the tender and the part on the locomotive. Accordingly, a ball-joint construction is provided at b_5, Fig. 3, where the conveyer and crusher unit on the tender is connected to the transfer hopper *b*. Fig. 7, view (*a*), shows the ball joint detached from the conveyer trough d_3, Fig. 3, and (*b*) shows

the two clamps which bolt to and connect the ball joint to the transfer hopper. The two clamps fit around the part b_5 of the ball joint. This arrangement, as well as the universal joint e, Fig. 3, at the conveyer drive and reverse, provides for the uneven movement between the tender and the locomotive without any strain on the parts connected.

The slack between the locomotive and the tender causes the part of the stoker on the locomotive to transmit a pull or a push to the part which is on the tender. Therefore, the

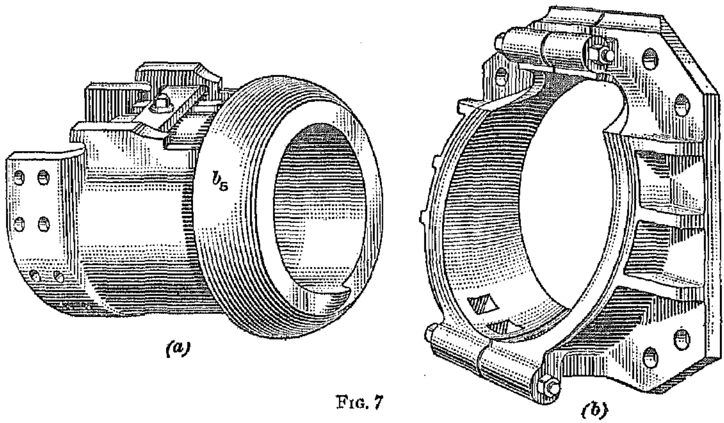


FIG. 7

conveyer and crushing unit A, Fig. 3, is not fixed but moves back and forth on the rollers c_9 (one on each side), which rest on angle supports e_2 riveted to the sides of the tender.

ARRANGEMENT OF STOKER ON TENDER

10. The arrangement of the conveyer and crushing unit on the tender is shown in Fig. 8. This unit is placed beneath a shovel sheet e which is provided with an opening 18 inches wide extending from the coal gates to the slope sheet of the tender. The opening is shown covered by slides e_1, which are about 20 inches wide. When starting out on a trip with a full tender of coal, the front slide is removed and the coal permitted to fall into the conveyer trough. The slides are

removed one at a time as the supply of coal in the tender decreases. When the tender is empty all the slides are replaced before coal is taken on. The conveyer unit is supported beneath the shovel plate on two angle supports e_2, which are riveted to the sides of the tender, the conveyer

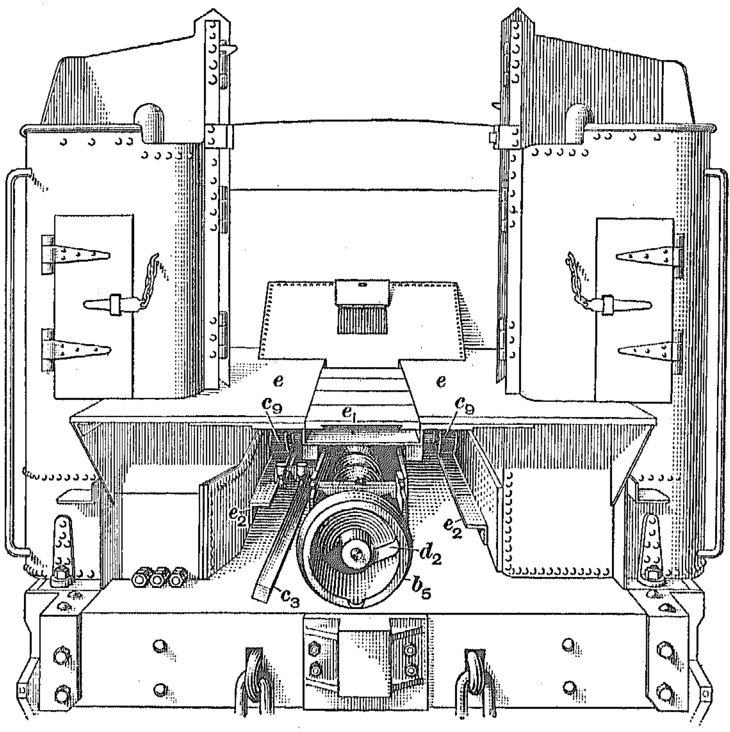


FIG. 8

slide support rollers c_9 resting on these supports, as shown. The rollers are fitted on axles on the conveyer so that the conveyer can move back and forth on the angles and thereby accommodate itself to the slack between the locomotive and the tender. The ball joint is shown at b_5. The front end of the conveyer screw d_2 is shown within the ball joint, and the flexible connection shaft by which the conveyer is driven is shown at c_3.

ARRANGEMENT ON LOCOMOTIVE

11. The arrangement of the stoker on the locomotive is shown in Fig. 9. The driving engine and the transfer hop-

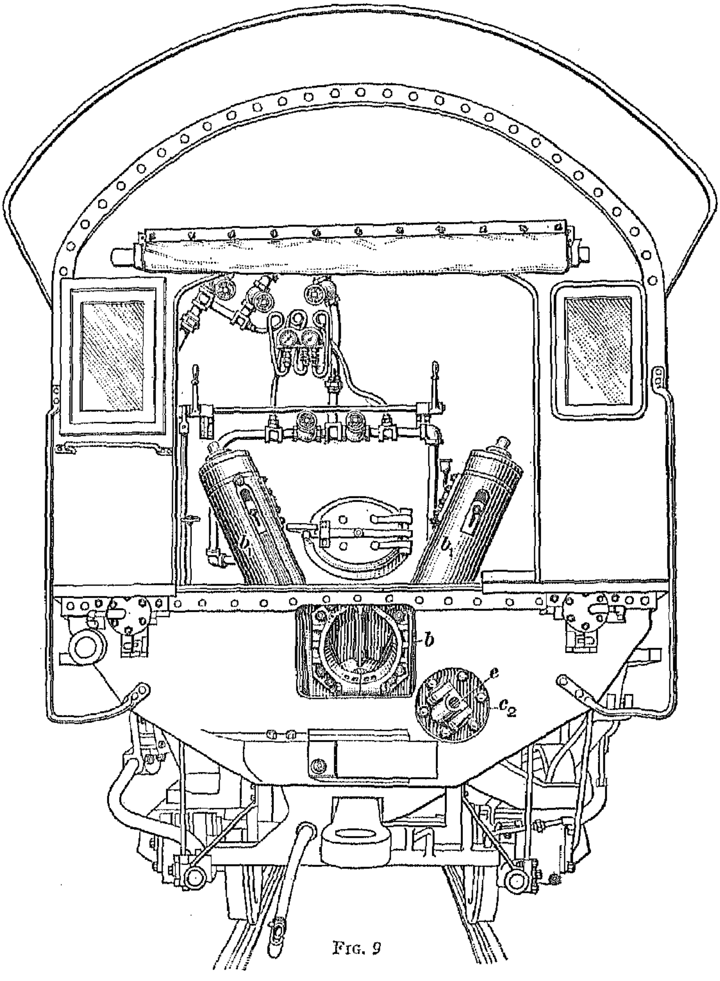


FIG. 9

per b are bolted to the frame beneath the deck of the locomotive. Access to the interior of the transfer hopper is obtained by two doors in the deck, which forms the top of

the hopper. The two elevator casings b_1 are placed on each side of the firebox door. The head for the conveyer drive and reverse c_2 with the universal joint connection is shown at e.

GENERAL OPERATION

12. The general operation of the stoker in transferring coal from the tender to the firebox will be explained by referring to Figs. 3, 4, and 5 (*b*). The coal falls by gravity through an opening in the shovel sheet into the conveyer trough d_3, Fig. 3, and is carried forward by the conveyer screw d_2 into the crushing zone. The coal is forced against the crushing plate d_{10}, where it is broken into lumps of a size suitable for firing, and it then passes into the transfer hopper b. The elevator screws b_2, Fig. 5 (*b*), lift the coal from the transfer hopper and throw it into the distributing system C, Fig. 4. The fuel is then blown through the distributer tubes e by steam from the jet nozzles e_1, and is distributed over the entire grate area.

THE CONVEYER SYSTEM

13. Parts of Conveyer System.—The conveyer system consists of two principal parts, a conveyer unit on the tender, and a conveyer drive and reverse on the engine. The conveyer unit conveys, crushes, and delivers the coal to the transfer hopper. The conveyer drive and reverse transmits the movement of the driving rack to the conveyer screw of the conveyer unit, and reverses the conveyer screw or stops it as may be desired.

THE CONVEYER UNIT

14. Arrangement.—A view of the conveyer unit detached from the transfer hopper is shown in Fig. 10. This unit consists of a heavy wrought steel trough d_3, a cast steel conveyer screw d_2, a flexible driving shaft c_3, and a rigid drive shaft c_4. These shafts drive the conveyer screw through the medium of the gears in the gear case d_7 at the rear end. The

shaft c_3 is connected to the shaft c_4 by a flexible connection c_6, which consists of a universal joint jaw, a block, and two pins. The conveyer flexible connection sleeve c_5 is shown on the end of the shaft c_3. The angle ring d_4 fits into and around the top of the trough. Springs supported in pockets d_5 on the trough hold the angle ring sealed up against the under side of the tender deck to prevent any coal from being lost

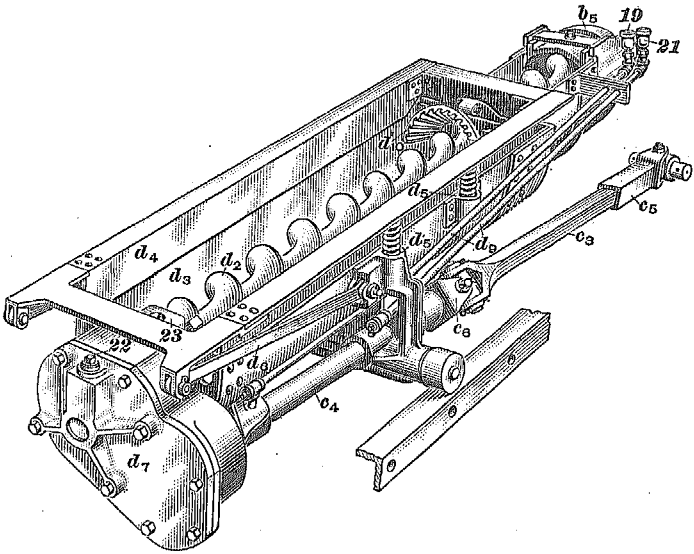


FIG. 1C

over the sides of the trough. The angle ring is shown removed in Fig. 11; the ring is connected to the trough by two hangers d_6.

The gears d and c_7, Fig. 3, are contained in the gear case d_7, Fig. 10. The gears are packed with grease before the casing cover is bolted on. Grease boxes *22* and *23*, which are cast in the gear casing and gear-casing cover, also permit of grease being forced into the gear case when the plugs are removed. The grease boxes should be filled once a month.

15. The bearings of the shafts c_3 and c_4 are lubricated by gravity through the pipes d_9. The ends of the pipes are pro-

vided with oil cups *19* and *21*, which can be reached by lifting the deck apron between the locomotive and the tender. The conveyer unit is flexibly connected to the transfer hopper

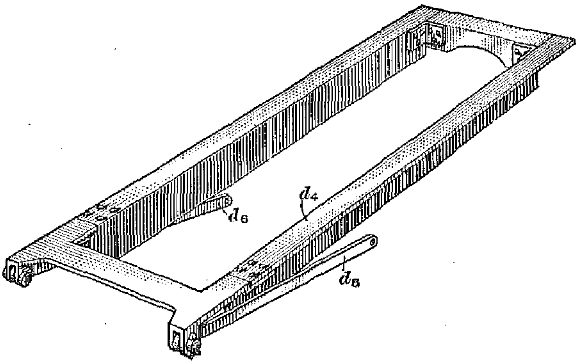


FIG. 11

by the ball joint b_5, which fits on the inside of two clamps bolted to the transfer hopper.

The crushing zone, which consists of a heavy crusher plate d_{10} with projections, is secured to the conveyer trough. The conveyer screw carries the smaller coal through the crusher without breaking it, but any large lumps are forced against the crusher plate by the conveyer screw, and there broken into a size suitable for efficient firing.

16. Flexible Drive Shaft.—The flexible drive shaft c_3, Fig. 10, is shown detached in Fig. 12. The front end of the

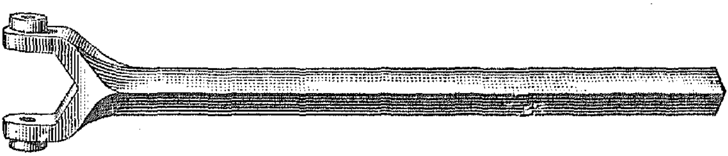


FIG. 12

shaft fits into the conveyer flexible connection sleeve c_5, Fig. 10, and the rear end is connected to the rigid drive shaft c_4 by a universal joint.

17. Rigid Drive Shaft.—The rigid drive shaft c_4, Fig. 10, is shown in Fig. 13 with the universal joint c_6 at one end and the gear c_7 at the other.

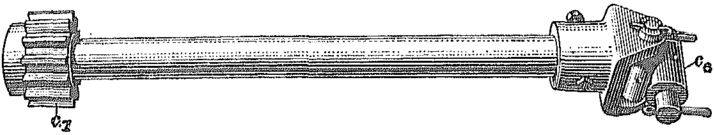


FIG. 13

18. Conveyer-Screw Shaft.—The conveyer-screw shaft d_1, Fig. 3, with the gear d on the rear and the coupling e_2 connected to the front end, is shown in Fig. 14. The coupling e_2 is secured to the shaft by keys and also by the bolt shown. The coupling is used to connect the shaft d_1 to the rear end of the conveyer screw. The front end of the shaft

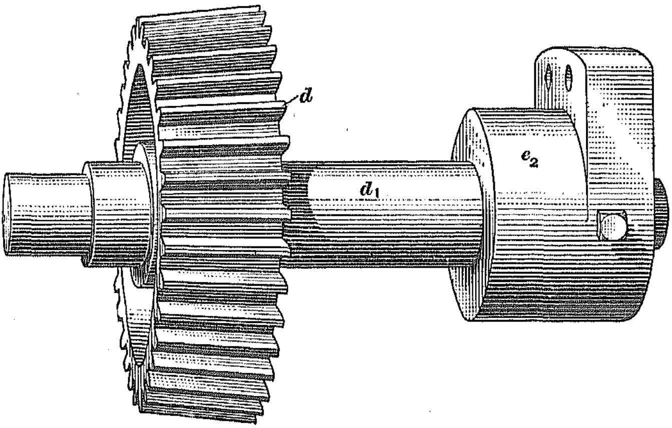


FIG. 14

fits in a hole in the end of the screw, and the collar and the screw are held together by bolts, two of the bolt holes being shown in the collar.

19. Conveyer Screw.—In Fig. 15 is shown the two end portions of the conveyer screw with the collar e_2 that connects the screw to the conveyer-screw shaft. The conveyer

screw forces the coal from the tender into the transfer hopper. The front end of the screw is larger than the other part, and this end forms a bearing in the ball joint in which it

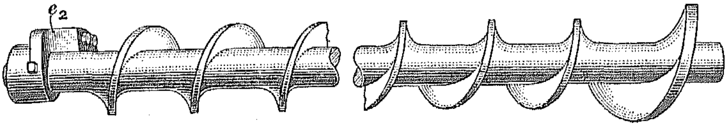


FIG. 15

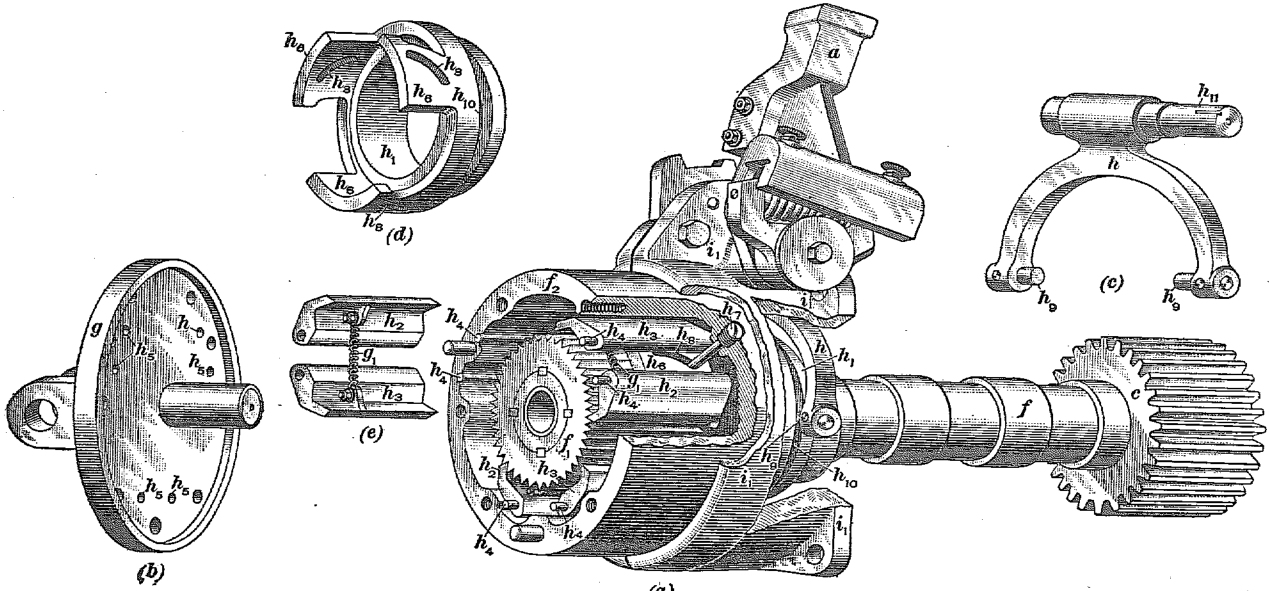
works. The larger diameter of the screw delivers the coal faster into the transfer hopper and thereby relieves the crowding of the coal forward of the crusher.

CONVEYER DRIVE AND REVERSE

20. Purpose.—The conveyer drive and reverse c_2, Fig. 3, as the name implies, performs the same function for the conveyer screw that the valve gear performs for the locomotive. By means of the conveyer drive and reverse, the conveyer screw may be caused to turn so as to deliver coal to the transfer hopper, the screw may be made to turn in the reverse direction and pull the coal back, or the conveyer screw may be stopped.

21. Views of Conveyer Drive and Reverse.—In Fig. 16 (*a*) is shown the conveyer drive and reverse partly assembled with a portion of the body f_2 broken away so as to show the interior. In (*b*) is shown the drive and reverse body head g which bolts on the end of the conveyer drive and reverse body f_2. In (*c*), (*d*), and (*e*) are shown removed some of the parts which make up the drive and reverse mechanism. Thus, (*c*) shows the shifting yoke which is marked h in (*a*); while (*d*) shows the pawl shifter h_1, and (*e*) shows the pawls h_2 and h_3.

In Fig. 17 (*a*) is shown a sectional view of the conveyer drive and reverse, and (*b*) shows the end of the device with the cover g, Fig. 16 (*b*), removed. The shifting yoke h is shown assembled in the conveyer reverse cover i_1 in (*c*).



a
h_8
h_8
h_9
h_6
h_{10}
h_1
h_6
h_8
(d)
h_{11}
h
(c)
h_9
h_9
g
h_5
h_5
h_5
h_5
(b)
h_2
g_1
h_3
(e)
f_2
h_4
h_4
h_3
h_8
h_7
h_6
g_1
h_2
i_1
i
h
h_1
f
c
f_1
h_2
h_3
h_4
h_4
i_1
h_9
h_{10}
i_1
(a)

FIG. 16

The shaft f, Fig. 17 (a), turns in a bushed bearing in the transfer hopper and in a bearing cover, not shown, but which bolts to the transfer hopper and therefore holds the conveyer drive and reverse in position. The flanged part of the conveyer reverse cover i_1, Fig. 17 (a), is bolted to the end of the part of the transfer hopper and the bearing cover which encloses the shaft f.

22. Arrangement of Parts.—Reference will be made to Figs. 16 and 17 when the arrangement of the parts of the conveyer drive and reverse is explained. Similar parts in both figures have the same reference letters.

The conveyer drive and reverse consists of a gear c, which is secured near the end of the shaft f; a ratchet wheel f_1, which is keyed and pressed on to the other end of the shaft; a drive and reverse body f_2; three drive pawls h_2; three reverse pawls h_3; a drive and reverse body head g; a shifting yoke h, which is connected to the reverse lever a, and a pawl shifter h_1. The drive and reverse body f_2 is bushed and fits on a bearing on the shaft f where the shaft passes through the body. The left end of the shaft is hollow and contains a brass bushing that provides a bearing for the stem shown on the drive and reverse body head, Fig. 16 (b).

The drive pawls h_2 and the reverse pawls h_3 are arranged in pairs, and each pair is connected by springs g_1. A set of pawls is shown removed in Fig. 16 (e). The upper one is the drive pawl, and the lower one the reverse pawl. The spring g_1 is held on the pawls, as shown. The drive pawls obtain their name from the fact that they engage the teeth of the ratchet wheel and cause it to turn the conveyer screw so as to move the coal forwards. The engagement of the reverse pawls with the ratchet wheel causes the conveyer screw to reverse and pull the coal back, hence their name.

23. The pawls are free to turn on pins h_4 that connect them to the drive and reverse body f_2. The front ends of the pins fit in holes h_5 in the drive and reverse body cover g, Fig. 16 (b), and the rear ends are driven into holes in the drive and reverse body.

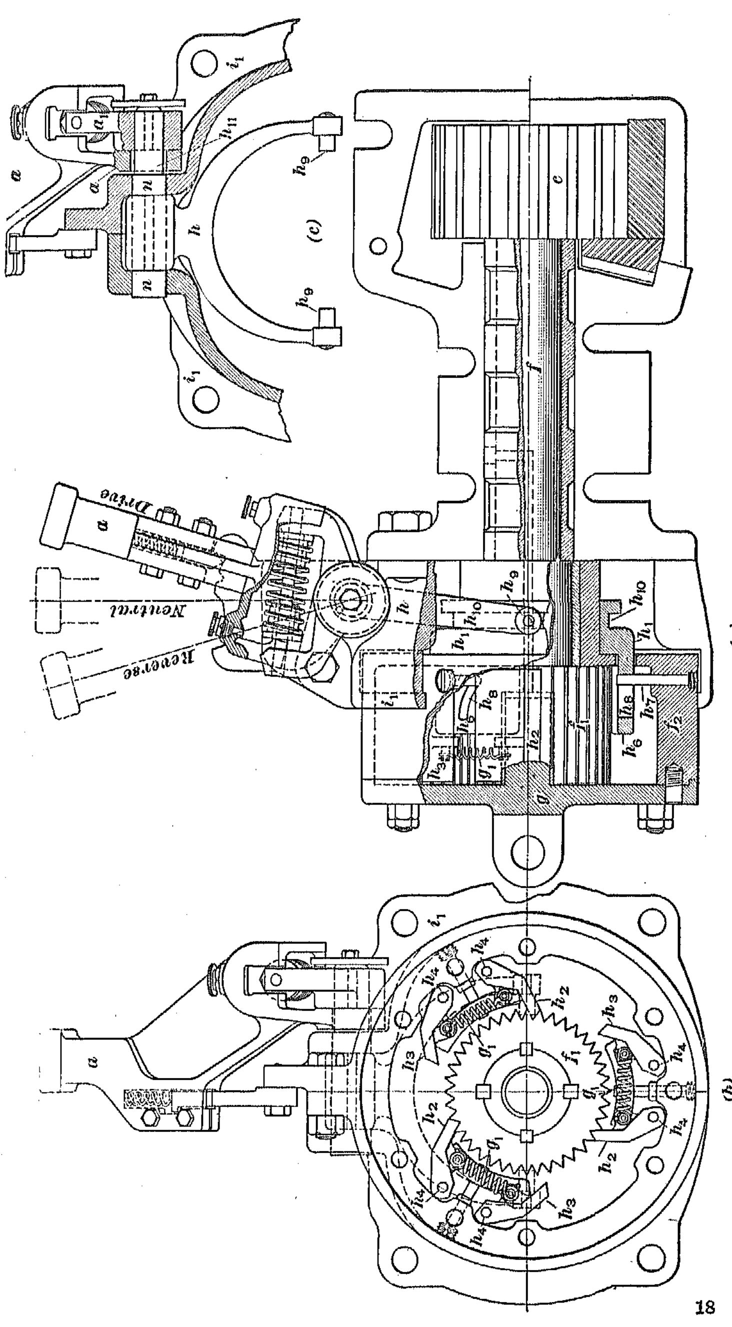


FIG. 17

The purpose of the pawls is to transmit the rotation of the ratchet wheel f_1 as it is turned by the gear c and the driving rack to the drive and reverse body f_2, because when a set of pawls are engaged with the teeth of the ratchet wheel, the wheel, the pawls, and the body really become one piece. If none of the pawls engage the ratchet wheel f_1, shaft f and the ratchet wheel will turn in accordance with the movement of the driving rack without imparting movement to the drive and reverse body f_2.

The shaft f passes through and fits loosely in the circular hole in the pawl shifter h_1, Fig. 16 (d). When the shifter h_1 is assembled on the shaft, Figs. 16 (a) and 17 (a), the three shifter fingers h_6 extend through slots in the drive and reverse body and come between each set of pawls. The pawl shifter is held in place in the drive and reverse body by three pins h_7, which are screwed into the outer rim. Each pin passes through diagonal slots h_8 in the shifter fingers h_6. The purpose of the pawl shifter is to bring the pawls into or out of contact with the ratchet wheel f_1.

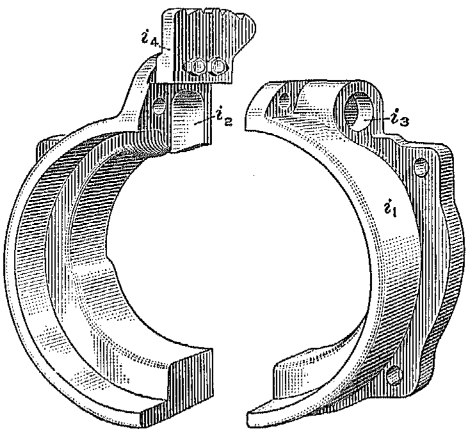


FIG. 18

24. The purpose of the shifting yoke h, Fig. 16 (c), is to move the pawl shifter into or out of the conveyer drive and reverse body. When assembled, Figs. 16 (a) and 17 (a), the shifting yoke h is placed around the pawl shifter h_1, and the two shifting yoke pins h_9, Fig. 16 (c), fit loosely in the groove h_{10} in the shifter in (a) and (d), Fig. 16. The pins are screwed into the arms of the shifter yoke. The arrangement of the shifting yoke in the pawl shifter is such as to permit the pawl shifter to rotate with the drive and reverse

body and yet allow the yoke to move the shifter in or out of the drive and reverse body when it is desired to do so. The shifting yoke is moved by the reverse lever *a*, which is connected to the part h_{11}, Fig. 16 (*c*), of the shifting-yoke shaft.

The shifting yoke *h*, Fig. 17 (*c*), is carried in, as well as enclosed, by the conveyer reverse cover i_1, which is made in two parts. The parts *n* of the shifting-yoke shaft turn freely in the reverse cover.

The conveyer reverse cover i_1 is shown in Fig. 18. The parts *n* of the shifting-yoke shaft, Fig. 17 (*c*), turn in the holes i_2 and i_3, Fig. 18. The long end h_{11}, Fig. 16 (*c*), of the shifting-yoke shaft extends beyond the hole i_3, and the reverse lever connects to the outer end. The reverse lever quadrant i_4 is bolted to one-half of the cover. The flanged part of the reverse cover i_1 bolts to the transfer hopper and the bearing cover, Fig. 17 (*a*).

REVERSE LEVER

25. Purpose.—The purpose of the reverse lever is to put the conveyer drive and reverse, and, therefore, the conveyer screw into drive, reverse, or neutral position. The reversal or stopping of the conveyer screw is accomplished by the movement the reverse lever imparts to the shifting yoke and, therefore, to the pawl shifter and the pawls. The reverse lever *a* has three positions: Fig. 17 (*a*), drive position with the lever pointing forward; reverse position with the lever pointing to the rear; and neutral position with the lever half way between drive and reverse positions.

26. Arrangement.—In Fig. 19 is given a side view of the safety reverse lever *a* and the rigid reverse lever arm a_1. The quadrant is marked i_4, the conveyer reverse cover i_1, and the end of the shifting-yoke shaft is marked *n*. Fig. 20 shows the other side of the reverse lever detached from the shaft of the shifting yoke with a part broken away. The reverse lever, Figs. 19 and 20, consists of two separate parts, the safety reverse lever *a* and the rigid reverse lever arm a_1.

The two prongs a_{10} and a_{12} of the rigid reverse lever arm fit in slots in the safety reverse lever, as shown. The safety reverse lever a turns freely on the shaft h_{11}, Fig. 17 (c), of the shifting yoke, but the rigid reverse lever arm a_1 is secured to the outer end of the shaft and is, therefore, used to turn it.

The upper end of the safety reverse lever works in a slot in the engine deck and is operated by a short bar a_2 provided for the purpose and which is removed except when the lever is being moved. The bar fits in a slot in the upper end of the lever. A spring behind the catch a_3, Fig. 19, holds it in contact with the notches in the quadrant and prevents the lever from being jarred out of position. The ends of the spring a_4, Fig. 20, encircle the two spring guide bushings a_5 and a_6, which slide freely on and are held in position by the pin a_7 in the rigid reverse lever a_1.

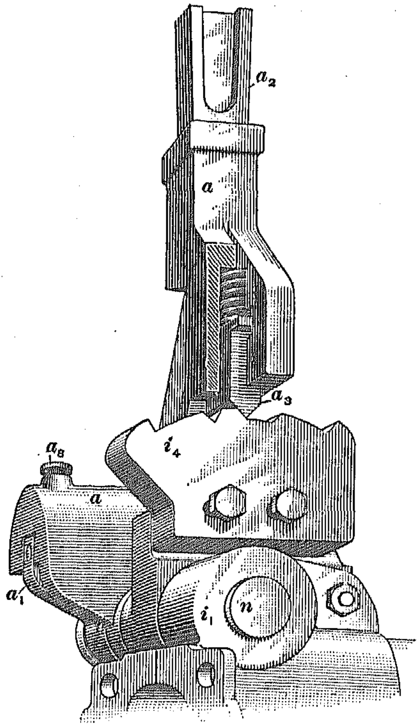


FIG. 19

The safety reverse lever a, Fig. 20, is used to compress the spring a_4, and the rigid reverse lever arm is moved by the force of the compressed spring and thereby transmits movement to the shifting yoke h, Fig. 17 (c). The oil plugs for oiling the pin a_7 are marked a_8, Fig. 20.

27. Operation.—Suppose in Fig. 17 (a) that the safety reverse lever a is moved forward. In this event the shoul-

der a_9, Fig. 20, of the safety reverse lever will be forced against the bushing a_5 and it will be carried ahead on the pin a_7, thereby compressing the spring a_4. The bushing a_6 will now be forced against the prong a_{10} of the rigid reverse lever arm a_1. When the pressure exerted by the spring a_4 on the rigid reverse lever arm a_1 is about equal to the resistance to movement offered by the pawl shifter and the pawls, the arm will move the shifting yoke. When the safety reverse lever is moved back, the part a_{11} of the lever is pressed against the bushing a_6. The spring a_4 is compressed and the bushing a_5 is forced against the prong a_{12} of the rigid reverse lever arm a_1 and will cause it to turn the shifting yoke.

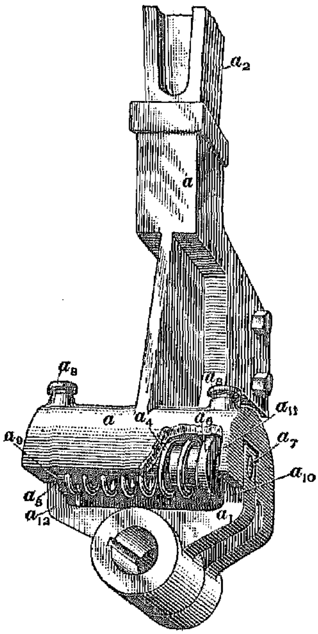


FIG. 20

The reason that the safety reverse lever imparts movement to the rigid reverse lever through a spring is to prevent damage to the shifting yoke, the pawl shifter, or to the pawls, should the latter stick in the teeth of the ratchet wheel. If the safety reverse lever were connected rigidly to the shifting yoke, some of the above parts would be broken, as the force transmitted through the lever would depend on the force applied to the reverse lever bar. When a spring is used, the force transmitted to the pawls does not depend on the pull on the safety reverse lever bar, but on the tension of the spring. The greatest force which can be applied to the pawls is, therefore, equal to that exerted by the compression of the spring a_4 when the safety reverse lever is at either extreme in the quadrant.

OPERATION OF CONVEYER DRIVE AND REVERSE

28. Positions.—The conveyer drive and reverse has three positions, drive or normal position, reverse position, and neutral position. In drive position the conveyer screw is delivering coal to the transfer hopper; in reverse position the conveyer screw is turning in the opposite direction and is pulling the coal back; and in neutral position the conveyer screw is stationary.

29. Conventional Views.—The operation of the conveyer drive and reverse will be explained by referring to Figs. 21, 22, and 23. These drawings are designed to show the operation of the apparatus rather than the actual construction, which has already been given in Figs. 16 and 17.

In Figs. 21, 22, and 23 (*a*) the pawls are not shown, and the purpose of these views is to show the movement of the pawl shifter h_1. Figs. 21, 22, and 23 (*b*) are end views of the conveyer drive and reverse, with the cover *g* removed. The reverse lever is not shown, because its position will be apparent from the positions of the shifting yoke *h*. A part of the driving rack a_3 is shown in contact with the gear *c*.

30. Drive Position.—In Fig. 21 (*a*) is shown the position of the pawl shifter h_1, and in (*b*) is shown the position of the drive pawls h_2 and the reverse pawls h_3 when the conveyer drive and reverse is in drive position. In drive position, the fingers h_6 (*b*) of the pawl shifter force the reverse pawls h_3 out of contact with the teeth of the ratchet wheel f_1, and the pawl springs, not shown, pull the drive pawls h_2 into contact with the wheel.

The outward or power stroke of the driving rack a_3 (*a*), as shown by the arrow, causes the gear *c* to turn the shaft *f* in the direction of the arrow on the shaft and the ratchet wheel (*b*) will turn as shown by the arrow *a*. As the drive pawls incline toward the direction in which the ratchet wheel is turning, they will mesh with the teeth of the wheel, and a turning movement will be transmitted to the drive and reverse

gear body f_2 in the direction shown by the arrow b. This rotation will be transmitted through the shafts and gears to the conveyer screw which will turn in the proper way to move the coal forward

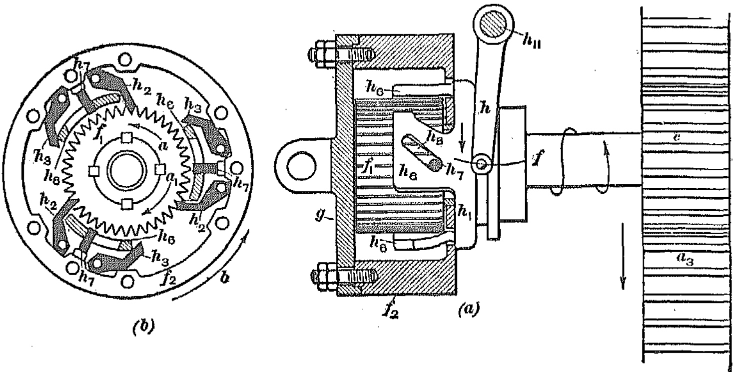


FIG. 21

When the driving rack a_3 moves in the opposite direction or inward, the ratchet will turn as shown by the arrow a_1 (b), but the drive and reverse body f_2 and the conveyer screw

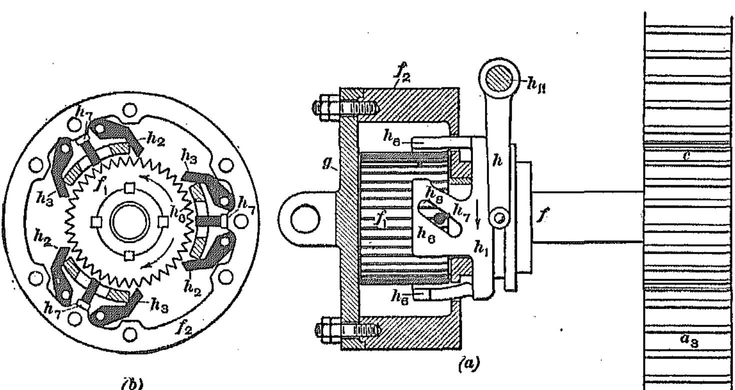
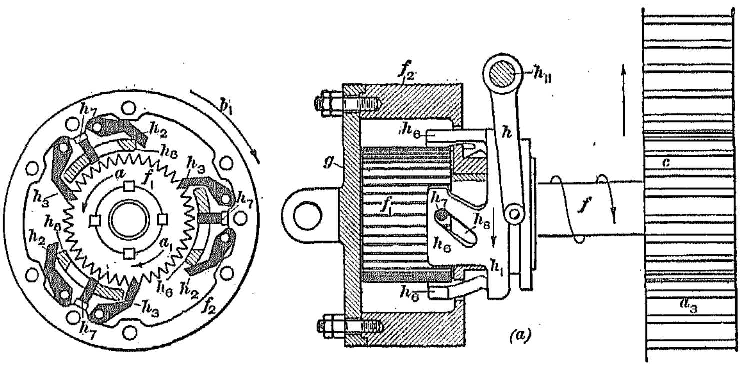


FIG. 22

stops. The reason is that the drive pawls h_2 are now inclined away from the direction of rotation of the ratchet wheel and they merely run over the teeth without sticking in them. This explains why the outward stroke of the driving engine

is a power stroke and the inward stroke is a light stroke. The non-engagement of the pawls with the ratchet wheel accounts for the clicking noise heard during stoker operation. The drive and reverse body and the conveyer screw begins to turn again when the driving rack starts outward.

31. Neutral Position.—When the reverse lever is pulled back to neutral position, the shifting yoke h and the pawl shifter h_1 are pulled outwards into the position shown in Fig. 22 (a). When the yoke is moving outward from the position shown in Fig. 21 (a) to the position shown in Fig. 22 (a), the engagement of the pins h_7 with the diagonal



(b) FIG. 23

slots h_8 causes the pawl shifter h_1 to turn within the shifting yoke h and the body f_2 in the direction of the arrow on the shifter. This movement of the pawl shifter causes the shifter fingers h_6, Fig. 22 (b), to force the drive pawls h_2 out of contact with the teeth of the ratchet wheel without bringing the reverse pawls h_3 against the teeth. The ratchet wheel f_1 then turns as shown by the arrows without imparting movement to the drive and reverse body f_2 and to the conveyer screw.

32. Reverse Position.—To reverse the conveyer drive and reverse body f_2, and, therefore, the conveyer screw, the outward or power stroke of the driving rack a_3, Fig. 21 (a), must be made a light stroke, and the inward or light stroke must be made a power stroke. Fig. 23 (a) shows how the

light stroke of the rack is converted to a power stroke and the rotation of the drive and reverse body as shown in Fig. 21 (*a*) reversed.

As the shifting yoke h is moved from the position shown in Fig. 22 (*a*) to the position shown in Fig. 23 (*a*), the pawl shifter h_1 moves outward and on account of the slots h_8 and pins h_7 continues to turn as shown by the arrow. The rotation of the shifter causes the shifter fingers h_6, Fig. 23 (*b*), to force the drive pawls h_2 still further away from the teeth of the ratchet wheel f_1 and the pawl springs, not shown, pull the reverse pawls h_3 into contact with the teeth.

33. The driving rack a_3, Fig. 23 (*a*), makes a power stroke when it moves inwards or in the direction of the arrow, because the ratchet wheel f_1, view (*b*), now turns in the direction of the arrow a_1 and engages with the reverse pawls h_3. The body f_2 will turn in the direction of the arrow b_1 and, therefore, the conveyer screw will turn in the opposite direction from drive position. The outward stroke of the driving rack and the ratchet wheel turning in the direction of the arrow a, Fig. 23 (*b*), is a light stroke, because the reverse pawls slip over the teeth of the ratchet wheel and do not stick in them.

When the shifter yoke is moved by the reverse lever from the position shown in Fig. 23 (*a*) to the position shown in Fig. 21 (*a*), the pawl shifter moves outwards and turns in the direction opposite to that of the arrow on the shifter, Fig. 23 (*a*), on account of the slots h_8 engaging the pins h_7. The reverse pawls h_3 are then thrown out of contact with the ratchet wheel and the drive pawls h_2 are pulled into contact as shown in Fig. 21 (*b*).

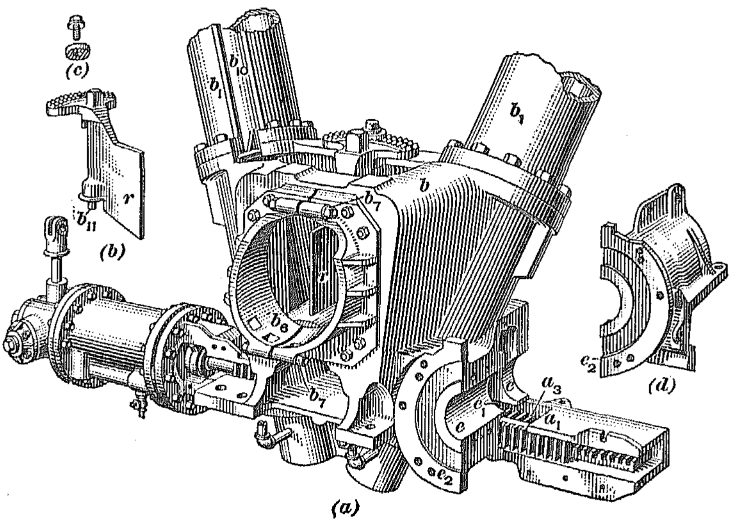
THE ELEVATING SYSTEM

34. Parts of Elevating System.—The elevating system *B*, Fig. 3, consists of the transfer hopper and the elevators. The transfer hopper receives the coal from the conveyer screw, and divides and delivers it to the elevators.

The elevators raise the coal from the transfer hopper to the distributer tubes which are attached to the elevators, and are set in openings in the back boiler head.

TRANSFER HOPPER

35. Description.—The transfer hopper *b* with the driving engine and driving-rack housing connected to it, are shown in Fig. 24 (*a*). View (*b*) shows the dividing rib and view (*c*) the stud and the washer for holding the rib fixed.



(a)

FIG. 24

In Fig. 24 (*a*) the conveyer drive and reverse is removed, and a part of the elevators b_1 is shown. In Fig. 25 is given a top view of the hopper with the elevators removed, but with the conveyer drive and reverse c_2 shown.

The shaft *f*, Fig. 16 (*a*), turns in a bushed bearing *e* in the side of the transfer hopper, Fig. 24 (*a*), and in the bearing cover, view (*d*). The bearing cover bolts to the side of the hopper and holds the conveyer drive and reverse in position. The flanged part of the conveyer reverse cover i_1, Fig. 17 (*a*),

bolts to the end e_2 of the hopper and the bearing cover. The conveyer drive and reverse gear turns in the opening e_1 and meshes with the teeth a_3 in the driving rack.

The transfer hopper is a large casting secured to the engine frame beneath the cab deck which forms a top for the hopper. Access to the interior of the hopper is obtained through two doors in the deck. The left and right ball-joint clamps b_6, Fig. 24 (a), which are bolted to the hopper serve to secure the ball joint on the conveyer unit to the hopper. The clamps are held together by the bolts b_7. The ball joint can be disconnected from the transfer hopper by removing the bolts

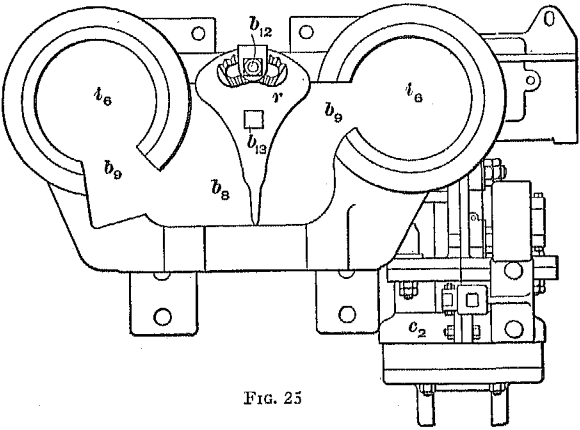


FIG. 25

which secure the left clamp to the hopper and the bolts b_7. The opening which is exposed in the top of the transfer hopper when the doors in the cab deck are opened, is shown by b_8, Fig. 25.

36. The openings b_9 are normally closed by the slide doors b_{10}, Fig. 24, on the elevators b_1. The lower part of the elevator screws work in the openings i_6, Fig. 25. The dividing rib r, Fig. 24 (b), shown in Fig. 25, is secured inside the hopper at the front on a pivot b_{11} on which it turns. The rib is held in position by a stud and washer b_{12}, Fig. 25, shown removed in Fig. 24 (c). The stud, Fig. 25, is set in a slot

in the rib, and the rib is held fixed when the stud is screwed down tight. To move the rib the doors in the cab deck are opened, the stud is slackened off by a wrench provided for the purpose, and the rib is turned by applying the wrench to the square projection b_{13}.

When the rib is turned to the left, more coal is supplied to the right elevator, and when the rib is turned to the right the coal supply is increased to the left elevator. The purpose of the dividing rib then is to control the supply of coal to either elevator.

THE ELEVATORS

37. Purpose.—The purpose of the two elevators, Fig. 3, which are placed on each side of the fire door, the elevator casings b being bolted to the transfer hopper, is to elevate the coal from the hopper and deliver it to the distributing system.

38. Description.—In Fig. 26 (a) is shown an exterior view of an elevator removed from the transfer hopper. In (b) is shown a section taken through an elevator, and in (c) a top view with a part removed so as to show the interior mechanism. Each elevator, view (a), consists of a casting i, an elevator screw i_1, a driving shaft i_2, with a gear i_3 connected to it, and an elevator drive and reverse i_4 which extends upwards from the line $x\,y$, and normally turns on the top of the elevator casing i during each power stroke of the driving rack.

The driving shaft i_2 transmits the movement of the driving rack, which meshes with the gear i_3, to the elevator screw. The upper end of the shaft i_2 extends beyond the top of the elevator drive and reverse. The elevator drive and reverse i_4 is a mechanism which is similar in principle to the conveyer drive and reverse, and is used to reverse or stop the movement of the elevator screw if desired. The lower ends of the driving shafts turn in bushings in the transfer hopper. The part of the elevator screw between the gear i_3 and the casing i turns in the semicircular cavity i_6, Fig. 25, in the transfer hopper.

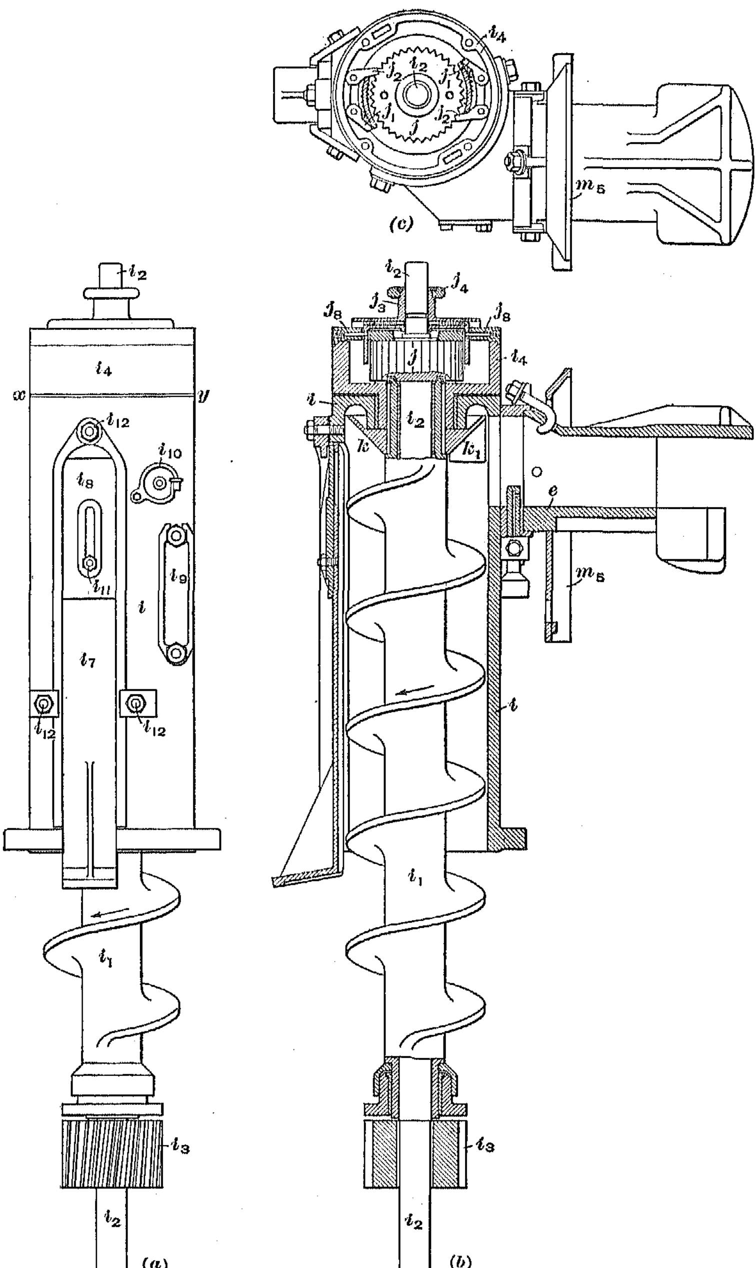

i_4
j_2
i_2
j_1
j_1
j_2
j
m_5
(c)
i_2
i_4
x
y
i_{12}
i_{10}
i_8
i_{11}
i_9
i
i_7
i_{12}
i_{12}
i_1
i_3
i_2
(a)
i_2
j_4
j_3
j_8
j_8
j
i_4
i
i_2
k
k_1
e
m_5
i
i_1
i_3
i_2
(b)

FIG. 26

39. The elevator casing, Fig. 26 (*a*), has an elevator door i_7, a slide door i_8, a casing door i_9, and a distributer cover i_{10}. The slide door i_8 which is slotted, is secured to the casing door i_7 by the stud and nut i_{11}. The door can be moved downwards by slacking off on the stud if the elevating screw becomes clogged. If the obstruction cannot be removed through the slide door, a larger opening can be made by removing the nuts i_{12}, and taking off the casing door i_7, the slide door also coming off with it. The elevator casing door i_9, which is secured to the casing by studs and nuts, is also provided to facilitate the removal of clogs from the elevators. The distributer cover i_{10} closes an opening through which the passage of coal to the distributers can be observed. A small poker can also be inserted through the opening if the coal is not moving freely at this point.

40. The arrangement of the moving parts of an elevator will be explained by referring to the sectional view of the elevator shown in Fig. 26 (*b*). The elevator driving shaft i_2 is placed within the elevator screw i_1, but these two parts are not secured together. The ratchet wheel j is keyed to the driving shaft i_2, and the pawl casing i_4 is keyed to the elevator screw i_1.

Fig. 26 (*c*) is a top view of an elevator with the cover removed and shows how the connection is made between the driving shaft and the elevator screw. The pawls j_1 and j_2 are pinned to the elevator pawl casing i_4, which in turn is keyed to the elevator screw. The ratchet wheel j is keyed to the driving shaft i_2 and transmits a turning movement through the pawls to the pawl casing i_4 and thereby to the elevator screw, when the ratchet wheel j is turned by the driving shaft i_2. The pawls can be moved into or out of contact with the ratchet wheel, thereby making and breaking the connection between the elevator screw and the driving shaft, by the pawl shifter j_3, Fig. 26 (*b*), which is raised and lowered by the reverse knob j_4.

41. Elevator Screws, Driving Shafts, and Elevator Casings.—In Fig. 27 (*a*) and (*b*) are shown the left and the

right driving shafts with the driving gears i_3 on their lower ends. In (*c*) is shown one of the elevating screws. The elevator casings are shown in (*d*) and (*e*). The screws are interchangeable, but the driving shafts are not. When assembled, the elevator screw fits loosely on the driving shaft. The elevator stirrer *k*, which has wings k_1, is keyed to the

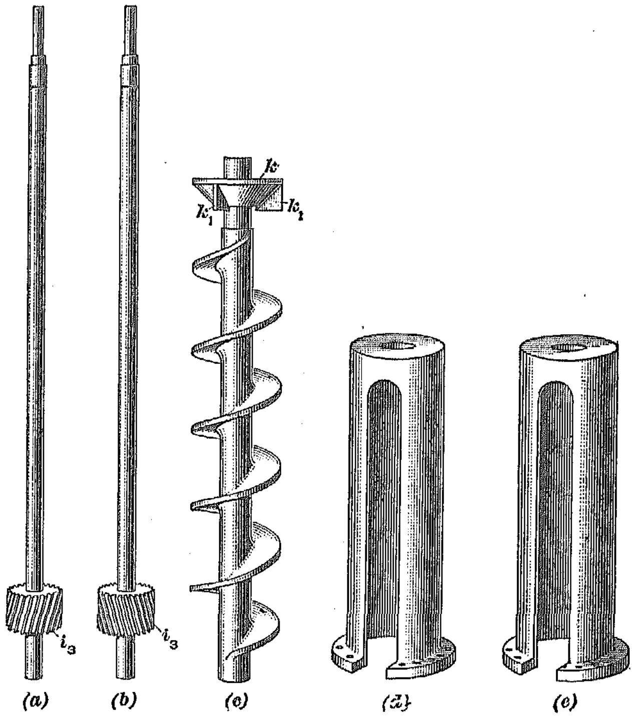


FIG. 27

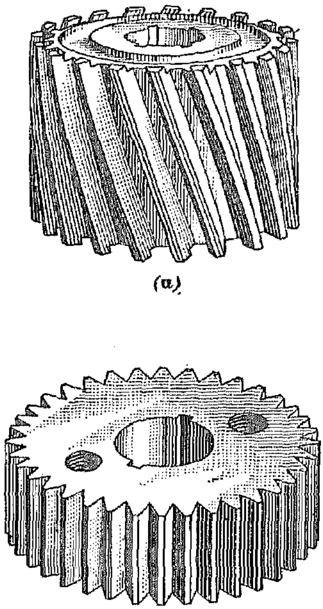
elevator screw. These wings, Fig. 26 (*b*), throw the coal after it has been elevated, into the distributer tube *e*. The elevator pawl casing i_4, Fig. 26 (*a*), turns on the top of an elevator casing, view (*d*) and (*e*).

Fig. 28 (*a*) shows the right elevator gear i_3, Fig. 27 (*b*), removed from the driving shafts. The gear shown has the teeth cut at $18\frac{1}{2}°$ and is used with a $18\frac{1}{2}°$ hopper. A $22\frac{1}{2}°$

hopper requires $22\frac{1}{2}°$ gears. Fig. 28 (*b*) shows the rachet wheel *j*, Fig. 26 (*b*), removed from the upper end of the driving shaft. The holes tapped in the wheel are used to remove the wheel from the shaft.

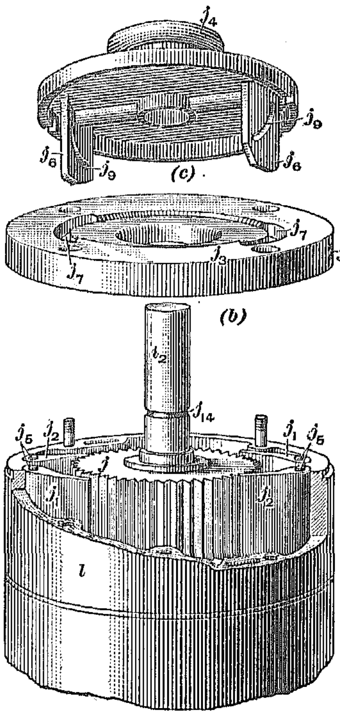
42. Elevator Drive and Reverse.—The elevator drive and reverse i_4, Fig. 26 (*a*) and (*b*), is a mechanism which normally turns on the upper end of each elevator casing. Its purpose is to run the elevator screw in either direction, or to stop it as may be desired.

The arrangement of the parts which comprise the elevator drive and reverse, will be explained by referring to Fig. 29 (*a*), (*b*), and (*c*), which show the mechanism partly disassembled. View (*a*) shows the elevator drive and reverse casing *l* partly broken away so that the interior can be seen; (*b*) shows the pawl casing cover, and (*c*) shows the pawl shifter. The ratchet wheel *j*, view (*a*), is shown removed in Fig. 28 (*b*). The pawls j_1 and j_2 turn freely on the pins j_5, which connect them to the casing *l*. The drive pawls which cause the elevator screw to turn so as to elevate the coal, are marked j_1, and the reverse pawls which cause the elevator screw to reverse and pull back the coal, are marked j_2.


(*a*)
(*b*)
FIG. 28

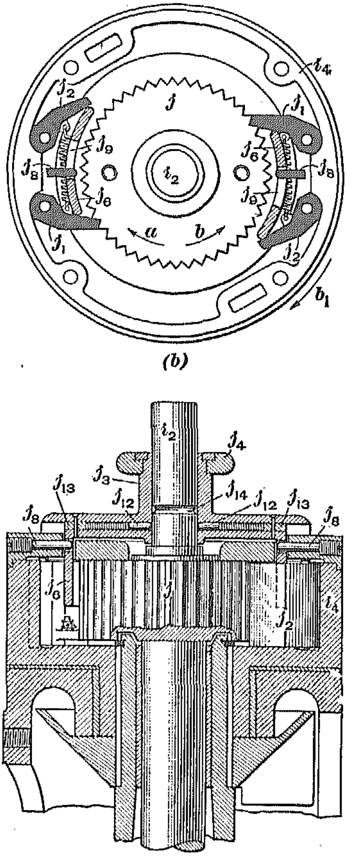
43. The pawls are connected by springs not shown in this view, but which are shown in Fig. 26 (*c*). The pawl cover j_3, Fig. 29 (*b*), bolts to the top of the casing *l*. The pawl shifter, view (*c*), sets on top of the pawl cover and the fingers j_6 extend down through the slots j_7 in the cover. The lower part of the fingers come between the pawls j_1 and j_2,

view (a). The pawl shifter, view (c), is held in the pawl cover by two pins j_8, view (b), one shown, the inner ends of which extend into the slots j_9, view (c), in the shifter fingers. The outer ends of the pinholes are closed by plugs.



(a)

Fig. 29



(a)

Fig. 30

The pawl shifter, Fig. 29 (c), has two catch pins j_{12} shown in the sectional view, Fig. 30 (a), with springs. The ends of the pins extend into the circular opening in the center of the shifter, Fig. 29 (c). The pins and springs are inserted by removing plugs j_{13}, as shown in Fig. 30. The pins hold the pawl shifter when it is raised to neutral position, as the

pins then engage with the groove j_{14}, Fig. 29 (*a*), on the driving shaft i_2. The pawl shifter can be raised and lowered by the reverse knob j_4, Fig. 29 (*c*), when the shifter is turning, because the knob is arranged so that it turns freely on the shifter.

OPERATION OF ELEVATOR DRIVE AND REVERSE

44. Positions.—The elevator drive and reverse has three positions, drive, or normal, position in which the coal is elevated; reverse position, in which the coal is pulled back; and neutral position, in which the screw is stopped. The elevator drive and reverse can be placed in any of these positions by moving the pawl shifter. The different positions will be explained by referring to Figs. 30 (*a*) and (*b*), and Figs. 31, 32, and 33 (*a*) and (*b*).

The elevator drive and reverse mechanism operates on exactly the same principle as the conveyer drive and reverse, except that two sets of pawls are used instead of three.

45. Drive Position.—Drive position will be explained by referring to Fig. 31 (*a*) and (*b*). In (*a*) is shown the position of the pawl shifter j_3 in drive position. In (*b*) the pawl cover is removed to show the position of the pawls with the pawl shifter, as shown in (*a*). The fingers j_6 of the pawl shifter in view (*b*) has thrown the reverse pawl j_2 out of contact with the teeth of the ratchet wheel j and the springs have pulled the drive pawls j_1 against the teeth. As the driving rack moves in and out, the driving shaft i_2 and the ratchet wheel will turn in one direction and then in the other, as shown by the arrows a and b. However, it is only when the wheel turns in the direction of the arrow a or toward the drive pawls j_1 that these pawls turn the pawl casing l and, therefore, the elevator screw. When the ratchet wheel turns in the direction of the arrow b the drive pawls run over the teeth without engaging them and the pawl casing l and the elevator screw remain stationary. With the ratchet wheel turning as shown by the arrow a, the casing turns in the proper direction as shown by the arrow a_1, for the screw to elevate the coal.

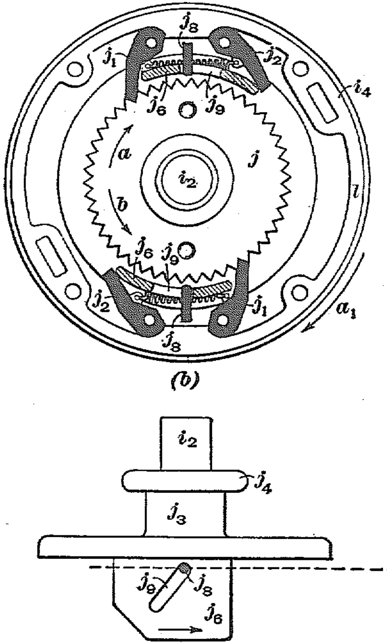


FIG. 31

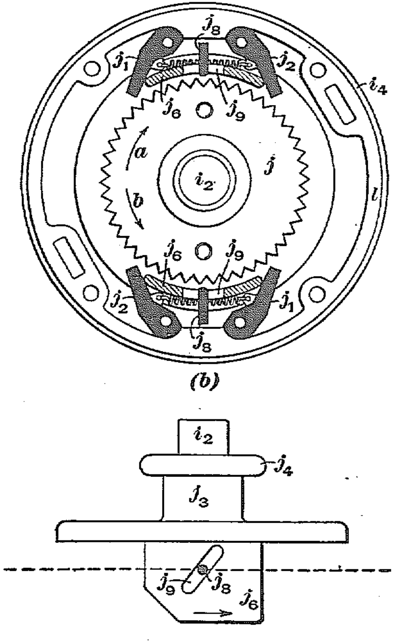


FIG. 32

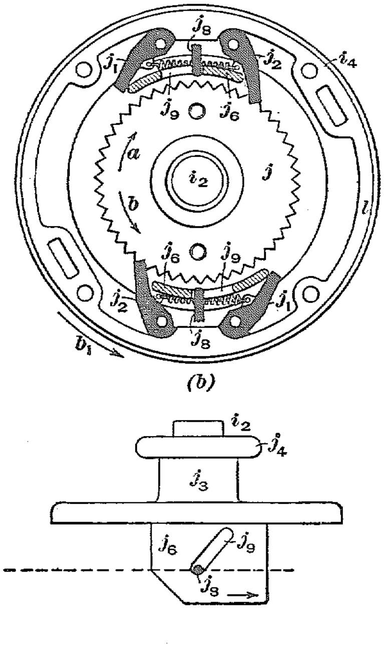


FIG. 33

46. Neutral Position.—Neutral position is shown in Fig. 32 (*a*) and (*b*). When the pawl shifter j_3 is lifted by the reverse knob j_4, view (*a*), the engagement of the slot j_9 with the pin j_8 causes the shifter to turn in the direction of the arrow. This movement, as shown in (*b*), causes the shifter fingers j_6 to throw both sets of pawls out of contact with the ratchet wheel j. Therefore, the ratchet wheel turns as before, but the pawl casing l and the elevator screw stop. The pins j_{12}, Fig. 30 (*a*), snap into the groove j_{14} with the pawl shifter j_3 in neutral position, and the shifter is held there.

47. Reverse Position.—Reverse position will be explained from Fig. 33 (*a*) and (*b*). When the pawl shifter j_3, view (*a*), is moved upwards by the reverse knob j_4, the shifter will again rotate in the direction of the arrow, and this movement brings the pawls into the position shown in (*b*). The fingers j_6 of the pawl shifter have now thrown the drive pawls j_1 out of contact with the ratchet wheel j, and the springs have pulled the reverse pawls j_2 against the teeth. While the ratchet wheel rotates in both directions, a turning movement is imparted to the pawl casing l only when the wheel turns in the direction of the arrow b, or toward the reverse pawls. The pawl casing and elevator screw, therefore, turn in the direction of the arrow b_1 instead of in the direction of the arrow a_1, Fig. 31 (*b*), and the coal is pulled back into the transfer hopper.

The pawl shifter must be held in reverse position because Fig. 30 (*a*) shows that there is no groove above the groove j_{14} for the pins j_{12} to catch in.

When the pawl shifter j_3, Fig. 33 (*a*), is lowered, the shifter turns in a direction opposite that shown by the arrow, and throws the reverse pawls j_2 out of contact with the ratchet wheel j. The springs will then pull the drive pawls j_1 in contact with the wheel, as shown in Fig. 31 (*b*).

48. Power Stroke and Light Stroke.—When the driving rack of the engine is making a power stroke, the ratchet wheel turns as shown by the arrow a, Fig. 31 (*b*). When the rack is making a light stroke, the ratchet wheel turns as shown

by the arrow b. In Fig. 33 (b) the arrow b shows the power stroke and the arrow a the light stroke. Moving the pawl shifter from drive position to reverse position, changes a light stroke of the driving rack to a power stroke and, therefore, reverses the movement of the elevator screw affected

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THE DISTRIBUTING, OR SPREADING, SYSTEM

49. Description.—The coal after leaving the elevating system, enters the distributing system which spreads it over the fire. The distributing system C, Fig. 4, consists of an arrangement of parts which are secured to the right and left elevator casings.

One of the distributing systems with the parts separated, is shown in Fig. 34 (a), (b), and (c). Each distributing sys-

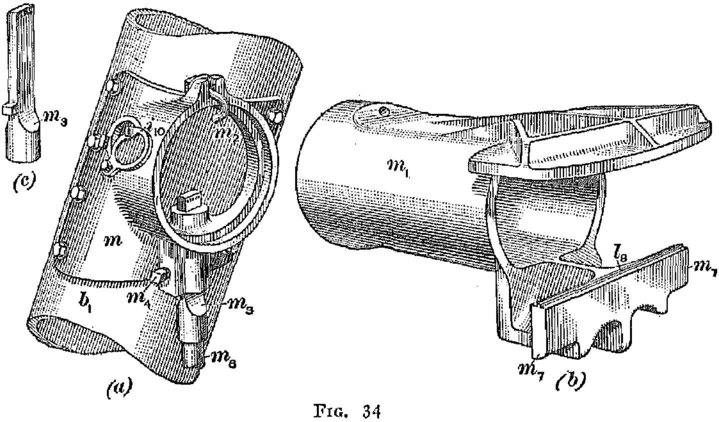


FIG. 34

tem consists of a distributer elbow m, view (a), which is bolted to the elevator casing b_1, partly shown; a distributer tube m_1, view (b), which is connected to the elbow by a hook bolt m_2; and a jet nozzle m_3, view (c), which is secured to the elbow by a setscrew m_4, view (a).

The distributer tube m_1, view (b), is now made in three pieces, the upper and lower parts on the front of the tube proper being removable. Therefore, should the parts which

extend into the firebox burn off, they may be replaced at a small expense and without the necessity of discarding the tube itself and installing a whole new distributer.

50. The distributer tube m_1 extends through an opening in the back boiler head into the firebox. The coal, as it is forced from the elevator screw into the distributer tube, is blown into the firebox by steam which passes through the small openings shown in the front of the jet nozzle. A draft ring m_2, Fig. 34 (*a*), is riveted to the boiler head and closes

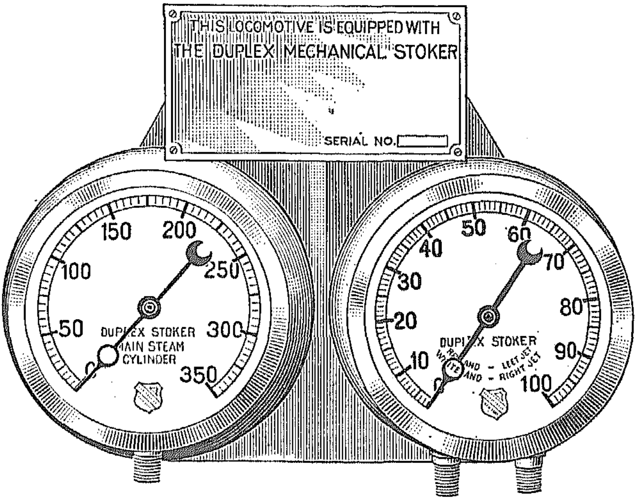


FIG. 35

the opening in the boiler head around the distributer tube. The lower end of the jet nozzles m_3 connect to steam pipes m_6. An opening extends upwards in each nozzle and terminates in the five small holes shown. The jet nozzle shown in (*c*) has a shoulder where it comes in contact with the elbows which permits the nozzle being maintained at the proper height. This fact is important, as any variation in the height of the jet nozzle in the elbow interferes with the proper distribution of the coal. The purpose of the distributer tubes is to scatter the coal evenly over the fire. The steam strik-

ing the ribs m_7, view (*b*), distributes the coal to each of the back corners, and the steam impinging on the rib l_8 scatters the coal over the other parts of the fire.

The firing of the coal is intermittent on account of the elevation of the coal being stopped during the return stroke of the driving rack. The passage of coal through the elbows can be observed by opening the cover i_{10}, view (*a*).

GAUGES

51. In Fig. 35 is shown the two steam gauges which are set in a bracket secured to the back head of the boiler in a position where they can be easily read by the fireman. The gauge on the left indicates the pressure of steam used by the driving engine. The gauge on the right has a red hand and a white hand, the one being above the other. The red hand indicates the steam pressure on the jet in the left elbow, and the white hand the pressure on the jet in the right elbow.

THE DRIVING ENGINE

52. General Description.—An exterior view of the driving engine has already been shown in Fig. 4. This figure shows the engine bolted to the driving rack housing, which is connected to the transfer hopper. Fig. 36 is a diagrammatic view of the left end or main cylinder head of the driving engine with the steam cylinder shown in section. This, as well as the views of the engine which follow, in Figs. 37, 38, and 39, are designed to show the arrangement of the various ports and passages, but not the actual construction of the parts.

The piston rod *a*, Fig. 39, which passes through a stuffing-box in the cylinder head, is screwed into the end of the driving rack a_3, and the piston is further secured to the rack by a lock pin a_4. The rack housing is marked a_2.

The cylinder of the driving engine has a stroke of $17\frac{3}{4}$ inches and a bore of 11 inches. The engine is operated by steam from the locomotive turret, the steam being reduced in pres-

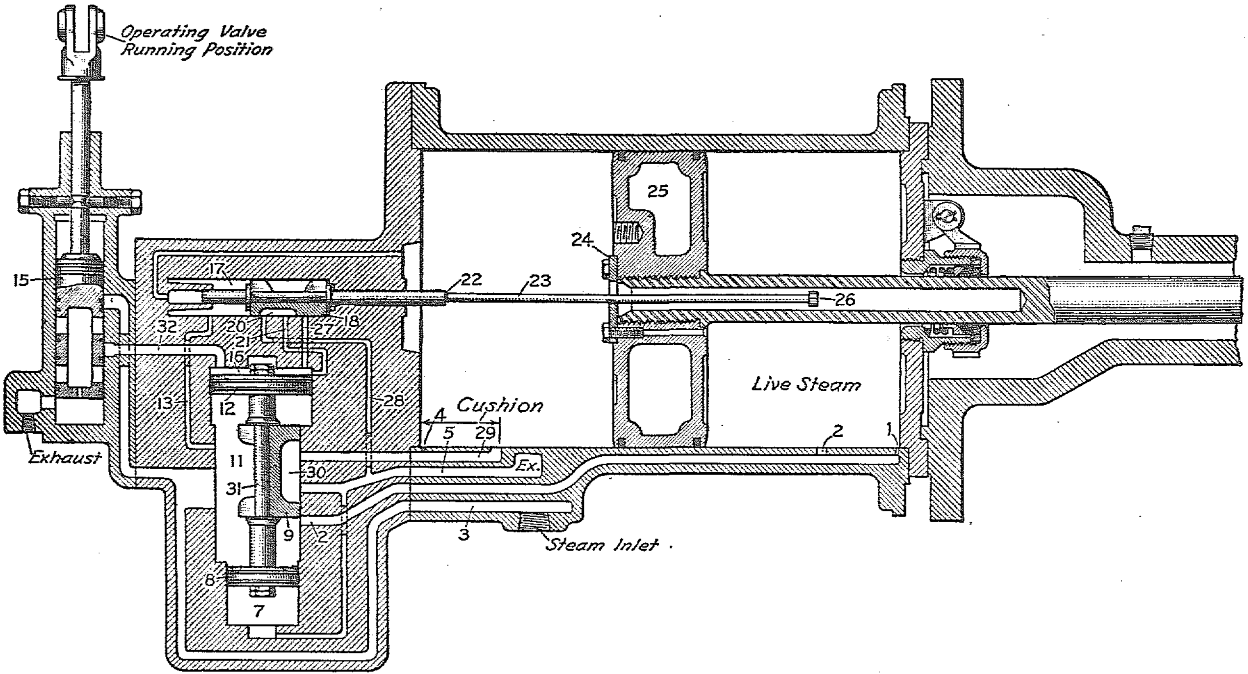

Operating Valve
Running Position
15
17
22
23
24
25
26
32
20
21
27
18
16
13
12
28
Cushion
4
5
29
Live Steam
2
1
Ex.
Exhaust
11
30
31
9
2
3
Steam Inlet
8
7

FIG. 36

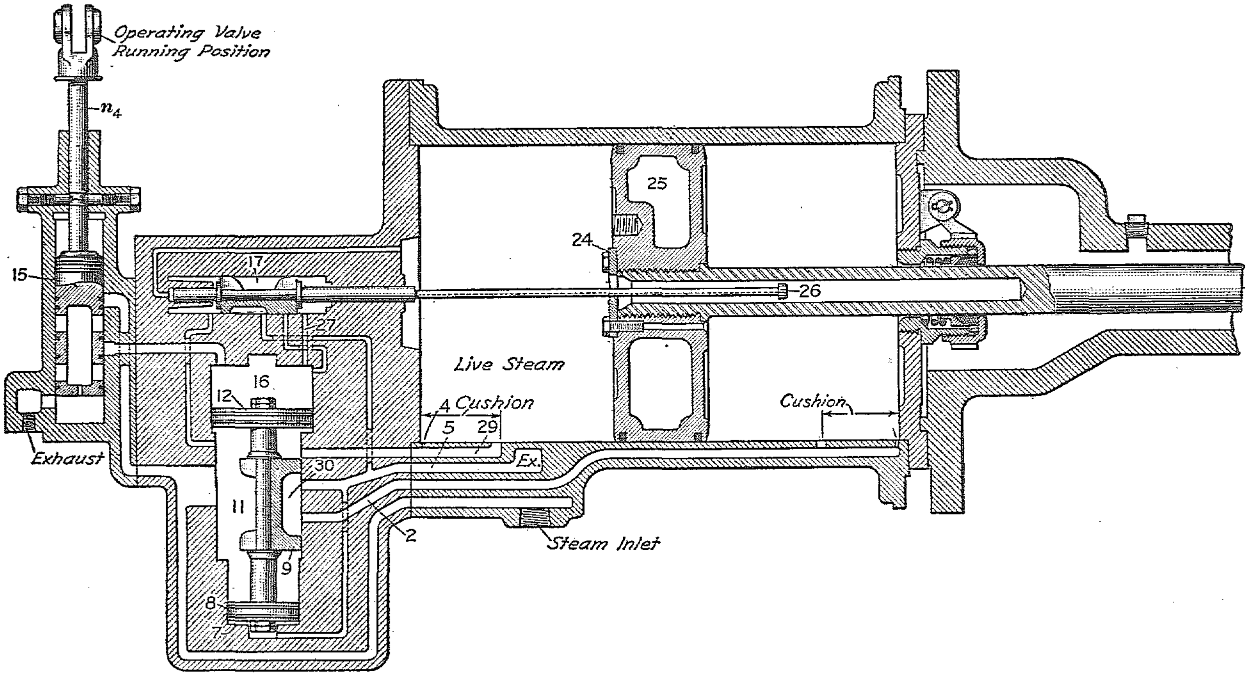

Operating Valve
Running Position
n_4
15
Exhaust
17
27
16
12
11
30
9
8
7
2
Steam Inlet
Live Steam
4
Cushion
5
29
Ex.
24
25
26
Cushion

Fig. 37

sure by throttling through a $\frac{1}{2}$-inch globe valve. A limiting valve is placed in the steam line to the steam cylinder, and is set to approximately 110 pounds, to prevent a high steam pressure and resulting strain on the stoker parts, should the pressure be suddenly turned on the cylinder with the main throttle valve. The steam pressure used varies from 8 to 80 pounds, according to the work required by the quality and size of the coal. In normal operation, that is when the stoker is conveying and elevating the coal, the piston makes a power stroke or turns the conveyer and elevator screws when it moves outwards or to the right. The piston runs light on the return stroke on account of the arrangement of the conveyer and elevator drive and reverse mechanisms, which causes the conveyer and elevator screws to remain stationary. However, as already explained, the reversal of the screws causes the piston to make a power stroke when moving to the left and a light stroke when moving to the right.

53. Operation of Stoker Engine.—The driving engine is practically the same as the top head and the steam cylinder of a Westinghouse single-stage air compressor. It will therefore be unnecessary to explain the constructon and arrangement of the parts in detail, as this will be evident when the operation is explained. The operation of the driving engine will be explained by referring to Figs. 36 and 37.

In Fig. 36 it is assumed that the steam piston *25* has stopped at the extreme right end of the cylinder. In this event the right side of the reversing plate *24* strikes against the button *26* on the reversing rod *23* and pulls the reversing valve *18* to the right into the position shown. This connects chamber *16* at the outer end of piston *12* to the steam exhaust port *Ex* through port *21*, cavity *20* in the reversing valve, and port and passage *28*. Steam from the boiler enters the driving engine at the port marked *Steam Inlet* and passes through passage *3* to chamber *11*, and through passage *13* to chamber *17*. On account of the area of piston *12* being greater than that of piston *8*, and because of the absence of

pressure in chambers *16* and *7*, the two pistons *12* and *8*, as they are connected by stem *31* on which a slide valve *9* is placed, are forced upwards. The slide valve *9* opens port *2* and steam passes from chamber *11* through passage *2* and ports *1* and *2* behind piston *25*, and forces it to the left. Any steam that may be in front of the piston exhausts through port *29*, cavity *30* in the slide valve, and through passage *5* to the exhaust *Ex.*

54. As the steam piston nears the end of the stroke to the left, the left side of the reversing plate *24* strikes the shoulder *22* on the reversing rod *23* and forces the reversing valve *18* ahead, as shown in Fig. 37. Steam from chamber *17* now passes through passage *27* to chamber *16* and practically balances the pressure on piston *12*, thus giving piston *12* no tendency to move in either direction. Therefore at this time piston *12* may be disregarded as far as any movement that it will impart to the slide valve *9* is concerned. The pressure then acting on the inner face of piston *8* as chamber *7* is always open to the exhaust, forces the pistons *12* and *8* and the slide valve *9* down, until the cavity *30* in the valve connects ports *2* and *5* and, therefore, the right end of the cylinder with exhaust port *Ex.* The slide valve now uncovers steam port *29* and steam from chamber *11* passes in front of the steam piston *25* and moves it to the right. As the piston nears the end of its stroke to the right, the right side of the reversing plate *24* strikes the button *26* on the reversing valve and pulls the rod and the reversing valve to the right, as shown in Fig. 36. The steam from chamber *16* exhausts through passage *21*, cavity *20* in the reversing valve *18*, and passage *28* to exhaust port *Ex.* The steam pressure in chamber *11* acting on the inside area of the large piston *12* moves pistons *12* and *8*, and slide valve *9* upwards. Steam then passes through passage *2* and ports *1* and *2* behind piston *25* and moves it to the left.

55. Cushion.—As the stoker engine has no air cylinder to supply an air cushion for the steam piston, a special port arrangement is provided in the cylinder so that the steam pis-

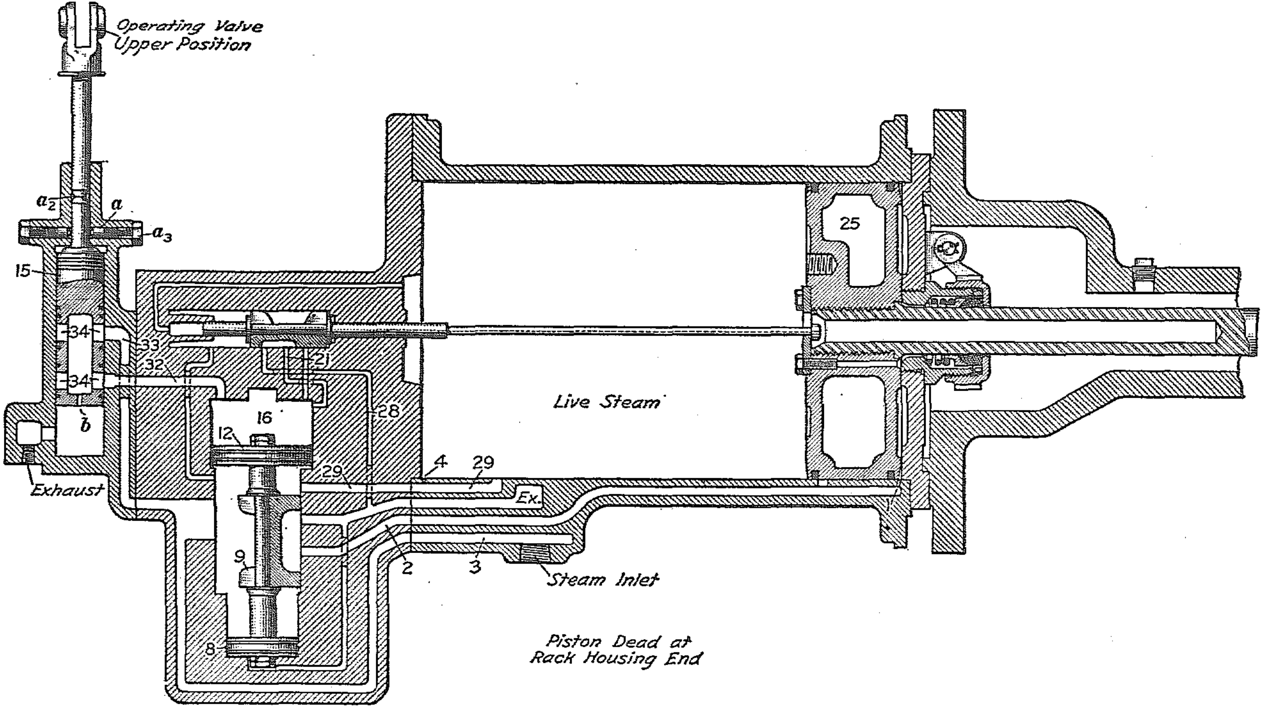
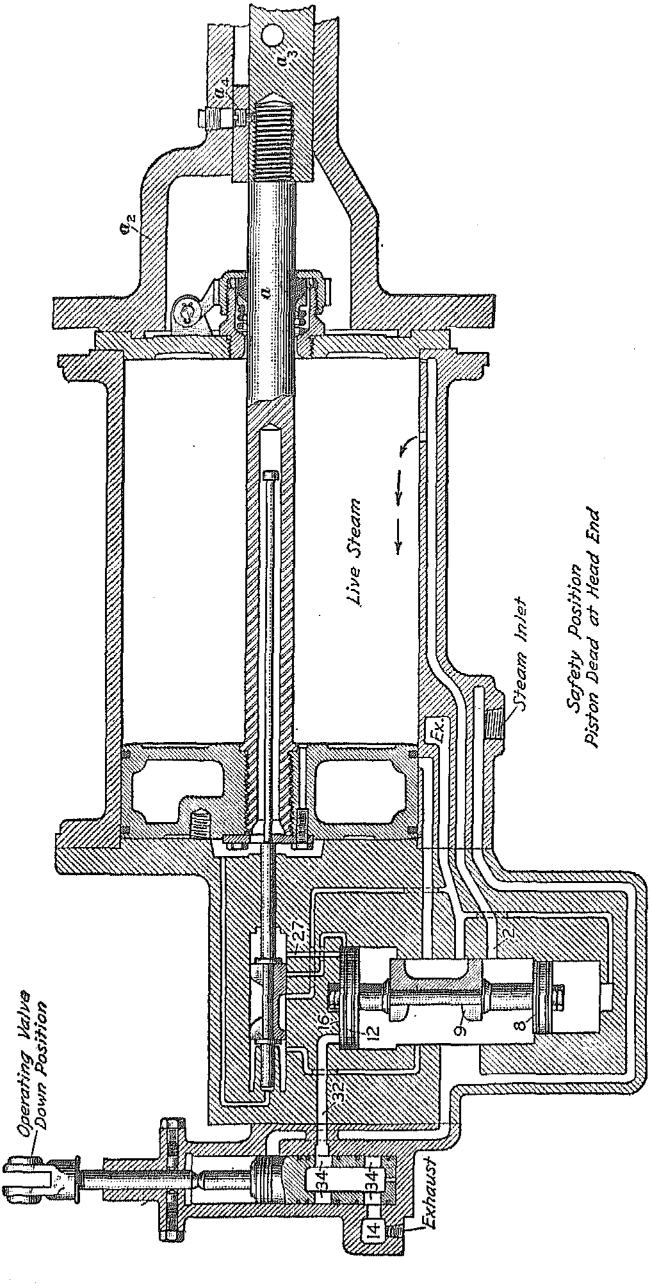

Operating Valve
Upper Position
a_2
a
a_3
15
34
33
32
34
b
Exhaust
21
16
12
28
9
8
29
4
29
Ex.
2
3
Steam Inlet
Live Steam
25
Piston Dead at
Rack Housing End

FIG. 38



Safety Position
Piston Dead at Head End

Fig. 39

ton can be properly cushioned at the end of either stroke. The port arrangement for cushioning the piston is as follows: Ports *2* and *29*, Fig. 36, from the steam passages enter the cylinder a short distance from either end. In addition to these ports, three small ports *1* and *4*, one of each being shown, which are $\frac{3}{16}$ inch in diameter, are drilled from the steam passages into the cylinder at either end. Therefore, when the steam is exhausting through ports *2* or *29* and the steam piston moves beyond these ports, any steam that remains in the cylinder is trapped between the piston and the cylinder head and escapes slowly through the small ports *1* or *4*. This action cushions the piston and prevents it from striking the cylinder heads. When the steam cylinder is receiving steam, the steam will enter the cylinder through ports *1* or *4* first. The piston, therefore, starts slowly, and a sudden thrust on the driving pawls is avoided until the piston moves beyond the large ports *2* or *29*.

OPERATING VALVE

56. Purpose.—The purpose of the operating valve *15*, Figs. 36 and 37, is to cause the steam piston to move back to the end of the cylinder, from which it last started, and to stop there. The necessity for such a movement of the steam piston under certain conditions will be understood from the following:

When the conveyer screw or either one of the elevator screws becomes clogged, and the engine and the screw stops, the screw which is clogged must be reversed to clear it. As the drive pawls will be held tight in the ratchet wheel of the part affected, the reverse arrangement of this part cannot be moved to disengage these pawls from the ratchet wheel. A movement of the steam piston and the driving rack in the opposite direction, is then necessary in order to relieve the pressure on the drive pawls. The purpose of the operating valve *15* is to cause the steam piston to return to the end of the cylinder from which it started, and then stop, which movement relieves the pressure on the drive pawls and thereby

permits the reverse lever of the conveyer drive and reverse or the pawl shifter of an elevator drive and reverse to be moved to reverse position. The engine can be started again by moving the operating valve to running position.

57. Positions of Operating Valve.—The operating valve is shifted by an arrangement of levers *10*, and rods n, n_1, n_2, and n_3, Fig. 5 (*a*). The rod n is secured by brackets to the back boiler head and the rod n_3 to a jaw on the operating valve rod n_4, Fig. 37. The operating valve lever *10*, Fig. 5 (*a*), has three positions: down position with the lever pointing down; upper position with the lever pointing up; and running position, with the lever pointing outwards. The lever is normally carried in running position. In down position the engine stops at the steam-head end of the cylinder. In upper position the engine stops with the piston at the rack end of the cylinder. In running position the engine continues to work.

58. Operation.—The action of the operating valve *15* will be explained by referring to Figs. 37 and 39, and Figs. 36 and 38. Let it be assumed in Fig. 37 that the piston, on account of a clog in the conveyer screw, stops in the cylinder on the outward stroke at the point shown. When the safety reverse lever is moved, the conveyer drive and reverse will not go into reverse position because the drive pawls are held fast in the teeth of the ratchet wheel. The operating-rod lever *10*, Fig. 5 (*a*), is moved downwards and places the operating valve *15* in the position shown in Fig. 39. The steam in the chamber in front of the large piston *12* now exhausts through port *32*, port *34* in the operating valve, and port *14* to *Exhaust*. Pistons *8* and *12* and the slide valve *9* will be forced upwards into the position shown, and steam will be admitted through port and passage *2* to the right end of the cylinder, thereby causing the piston to move back from the position shown in Fig. 37 to the left end of the cylinder, as shown in Fig. 39, where it will stop. The reverse movement of the piston and rack will free the drive pawls from the ratchet wheel and will permit the reverse lever to

move the pawl shifter to reverse position and thereby bring the reverse pawls into engagement with the ratchet wheel.

The reason the piston stops in the head end of the cylinder, as shown in Fig. 39, is that the steam which the reversing valve admits through port *27* to the front of the piston *12*, will escape through port *32* and the operating valve faster than it enters through port *27*. The pistons *8* and *12* and the slide valve *9* will, therefore, remain in the position shown when the steam piston completes its stroke to the left, and steam will continue to blow through port *14*. In order to get the piston to moving and, therefore, to run the conveyer screw backwards, it is necessary to move the handle of the operating-valve rod to running position. This moves the operating valve to the center position shown in Fig. 37, and the piston will again operate, because the escape of steam from chamber *16*, Fig. 39, is prevented. The reverse movement of the screw will force the obstruction out of the crusher where the clog usually occurs, when it can be removed from the trough.

59. When the conveyer screw has been reversed on account of clogging, if the reversed screw is run for more than one or two revolutions, the screw will wedge the coal at the back end, and the steam piston will stop. The reverse pawls will be held so tightly in the ratchet wheel that the reverse lever cannot move the shifting yoke and pawl shifter to drive position. Assume that the piston stops on the inward stroke in the position shown in Fig. 36. The handle *10* of the operating-rod lever, Fig. 5 (*a*), is moved to the upper position, which raises the operating valve *15* to the position shown in Fig. 38. Steam at boiler pressure then passes from the main steam passage *3* through passage and port *33* to ports *34* and passage *32* to chamber *16*, and the pistons *8* and *12* and the slide valve *9* are moved downwards from their position in Fig. 36 to their position in Fig. 38. The steam then enters the left end of the cylinder through port *29* and moves the piston to the right end of the cylinder. The movement frees the reverse pawls from the ratchet wheel and permits the

reverse lever to be moved to drive position. The steam piston will stop in the position shown in Fig. 38, because the steam will enter chamber *16* by way of the operating valve *15* faster than it can escape through ports *21* and *28* and the exhaust port *Ex.* To start the engine the operating-rod handle is returned to running position and this returns the operating valve *15* to central position, as shown in Fig. 36. In this position the admission of steam through port *32* is prevented. The same procedure should be followed when a clog occurs in either of the elevator screws. The operating valve, when in running position, is held there by two catches a, Fig. 38, one on each side of the rod, which are pressed by springs against the groove a_2 in the valve rod. The springs and catches can be removed by unscrewing the cap nuts a_3.

The purpose of the small port b in the valve shown in Fig. 38 is to unbalance slightly the steam pressure on the interior of the lower end of the valve when in its upper position and thereby prevent any tendency on the part of the weight to move the valve downwards.

METHOD OF OPERATION

60. To Stop and to Start Stoker Engine.—Reference will be made to Fig. 5 (a) and (b) when explaining how the stoker engine should be started. This illustration shows the arrangement of the steam pipes as well as the location of all the valves which are to be used when running the stoker. The operating valve lever *10*, views (a) and (b), should first be placed in central or running position. This operation puts the operating valve in the engine in the proper position to keep the engine running. Next the conveyer reverse lever c_8, view (b), should be placed in forward position, and valve *8* to the exhaust line opened. The drain cock c, view (a), in the drain pipe c_1 should also be opened. The drain cock c_2 on the cylinder is automatic. Then valve *1* at the steam turret, valve *2* when used, and valve *3*, are opened, which allows the steam to flow to the jet line through the pipes a. The valves *4* and *5* in the steam line which

regulate the steam pressure to the jet nozzles are left set when stopping the stoker, and they are, therefore, set for about the right pressure (8 to 20 pounds).

61. After it has been ascertained that steam is blowing through the jet nozzles, the steam may be turned on the engine by opening valve *6*, which allows the steam to pass to pipe *b*, the lubricator feed which is connected to pipe *11* being started first. Valve *7* is opened only when it is required to supply more steam than can be supplied by valve *6* on account of having to crush a hard lump of coal. After this has been done valve *7* should be closed.

Valve *9*, Fig. 5 (*a*) and (*b*), which is in a pipe leading to the transfer hopper, should be kept closed except when it is desired to moisten the coal with the exhaust steam from the stoker engine.

After the engine has been started the first slide plate in the tank should be opened by pulling it forwards with a hook. The amount the plate should be opened will depend on the size of the coal, but with slack coal the proper opening is obtained when the slide is open about half way.

To stop the stoker engine close valve *6*.

62. To Reverse Conveyer Screw in Tank.—The conveyer screw can be reversed by lowering handle *10* to bottom position. This stops the engine and frees the drive pawls, so that the reverse lever can move the shifting yoke. The lever c_8 is next moved to reverse position, and the engine started by moving handle *10* to center position. The screw should not be run backwards more than three revolutions.

On United States standard locomotive the handle *10* should first be raised instead of lowered, after which it is lowered to center position.

63. To Stop Conveyer Screw in Tank.—To stop the conveyer screw in the tank, the conveyer reverse lever c_8 should be moved to center position. If the lever cannot move the shifting yoke and pawl shifter on account of the pawls sticking in the ratchet wheel, handle *10* of the operating rod should be moved as explained in Art. **62.**

64. To Reverse Right or Left Elevator Screw. Before reversing the right or left elevator screw, the conveyer screw is stopped as explained in Art. **63** as otherwise the stoker will be jammed with coal. The elevator screw is then reversed by raising the elevator pawl shifter b_4 to upper position, where it will have to be held. If the pawl shifter cannot be moved, operate lever *10* as explained in Art. **62**.

65. To Stop Right or Left Elevator Screw.—The conveyer screw must be stopped before stopping either one of the elevator screws, or the stoker will become jammed with coal. Either elevator screw may then be stopped by raising the pawl shifter b_4 on the screw to be stopped to middle position.

66. Oiling the Stoker.—Unless stated otherwise, the oil used in lubricating the stoker refers to engine oil. The instructions for lubricating the stoker are as follows:

The driving-rack housing and the driving rack are oiled by putting $\frac{1}{4}$ pint of oil in cup *24*, Fig. 5 (*a*). After the first oiling the oil should be applied at intervals. The left lower elevator-shaft bushing is oiled through oil cup *17*. The left and right elevator casings b_3 are oiled by lifting the pawl shifters b_4 and pouring in $\frac{1}{8}$ pint of oil. The small oil holes *27*, Fig. 5 (*a*), are provided to oil the casings where the elevator drive and reverse rotates.

67. The oil box *15*, Fig. 5 (*a*) and (*b*), is filled by opening the door in the deck. The four pipes shown connected to this cup supply oil to the driving rack, to the right lower elevator-shaft bushing, and to each end of the conveyer drive and reverse. The bearings of the shafts c_3 and c_4 are oiled through cups *19* and *21*, access to which is obtained through the door in the deck. The universal joints e and c_6, the slip joint c_5, and the conveyer support rollers c_9, Fig. 5, should be oiled once a day. The ball joint and clamps b_5 (*a*), where the conveyer unit is connected to the transfer hopper, should also be oiled. The conveyer gears case cover should be removed

and the case which houses the gears *d* and c_7 filled with soft grease. The case should be inspected every 60 days. Additional grease can be applied through plugs *22* and *23*. The stoker engine should be fed two or three drops of valve oil a minute through the pipe *11*, which is connected to the stoker lubricator in the cab.

STOKER FIRING

68. Preparation for Trip.—Before a stoker can be operated successfully, the fireman should know the location and the purpose of all the operating levers, valves, gauges, and oil feeds to the different bearings.

When coming on duty, the parts of the stoker that require lubrication should be oiled. Assume that the tender slides are all in place and no coal entering the conveyer trough. Start the stoker and make a test of the parts by which it is controlled. The conveyer drive and reverse should be tested by placing the reverse lever in drive position, in reverse position, and then in neutral position, noting whether the lever moves freely and whether the conveyer drive and reverse can be reversed and stopped. Neutral position is important because the conveyer screw must be stopped before foreign matter can be removed from the transfer hopper or the elevators cleaned out. Then try the neutral positions on both elevators, as it is often necessary to cut out one side or the other, and the drive and reverse positions as well. Then, too, see whether the engine can be stopped and started by the operating lever.

69. After testing thoroughly the conveyer and the elevator screw controls, the stoker can be slowed down or stopped and the steam valve to the distributers opened. The steam should blow freely through all the holes in the jet nozzles, as otherwise the coal will not be properly distributed. Any holes which are stopped up should be cleaned out. The condition and the position of the distributers should be noted, because a distributer that is too low or one that is badly worn or burnt will not distribute coal properly.

After it has been found that the stoker operates properly, the fire should be built up by hand to about the same depth as if the engine were to be hand-fired. Any banks should be broken up and scattered over the grates. If the fire is too thin, small amounts of coal should be applied with the shovel. When the engine is ready to start the train, the fire should be level, light, bright, and well burned through. Before coupling on to the train the first tender slide should be opened and the stoker run until coal appears at the distributer elbows. The coal will then begin to go into the firebox as soon as the stoker is started.

70. **Operating the Stoker.**—When the engine has started the train, the stoker should not be started for a few minutes. This allows the coal in the firebox to become well burnt; the exhaust will remove the fine dirt and ashes from the fire, and a clean, bright fire will be obtained before the stoker is started. The stoker should now be started and allowed to work only a few minutes, after which it should be shut off and the fire carefully examined to see whether the entire grate surface is being lightly sprinkled with coal. The stoker should not be run rapidly, especially when starting out. For the first mile or so the stoker should be stopped frequently, the fire examined for unequal distribution of coal, and the pressure on the steam jets regulated so that too much coal will not be fed to any one part of the fire. If there is too much pressure on the jets, the coal will be thrown to the front end of the firebox and the fire at the back end will become too light. Cold air will then be admitted through the back grates and the steam pressure will drop.

If too little pressure is used on the jets, the fire will become too light on the front grates and too heavy on the back grates. Great care should, therefore, be given to the jet pressure so that the coal will be scattered evenly.

The pressure on the steam jets depends on how the locomotive is working and on the size and condition of the coal. Less steam-jet pressure is required when the locomotive is working hard, as the heavier exhaust assists in carrying the

coal into the firebox. When the coal is fine or dry, less steam-jet pressure is required than when the coal is wet.

The fire should be carried as thin as possible. Under average conditions the fire should be 5 or 6 inches deep at the fire-door and 3 or 4 inches deep at the flues.

71. The shovel should not be used after the stoker has been started, as green coal will fall on green coal and the resulting bank in the fire will necessitate the use of the hook. The exhaust at the smokestack should be watched closely. Dense black smoke is an indication that too much coal is being fired, and the stoker should be run more slowly. The coal should be watched as it runs from the tender into the conveyer for rock, to see that sulphur, pieces of wood, or iron, are removed before they enter the trough. Most of the stoker failures are caused by clogs of foreign matter in the coal. The fire should be starved as much as possible and only enough coal fed to maintain the steam pressure. If more coal is feeding to one side of the firebox than to the other, raise the hopper door and move the dividing rib toward the side that is receiving the most coal.

72. The elevator on the thick side of the fire may also be placed in neutral position for short periods from time to time, and the amount of coal fed to this side of the firebox decreased. As the conveyer screw will carry the coal to the transfer hopper faster than the single screw will elevate it, an elevator should not be stopped for any great length of time or the screw which is operating will stall because the hopper will become jammed with coal.

73. When approaching the top of a hill or a siding or other points where the throttle is to be closed, the stoker should also be shut off and the fire kept up by hand while drifting down hill or standing in the siding. The reason for shutting off the stoker is that the distribution of the coal is assisted by the draft when the engine is working. There is little or no draft when the engine is drifting or standing; hence, if the stoker is worked, the coal will bank in the firebox and may cause clinkers.

The fire should be maintained with the shovel when standing, drifting, or doing short switching. The shovel should also be used to hand-fire spots in the firebox which may be thin or undersupplied by the stoker.

On account of the thinness of the fire, greater care should be exercised when shaking the grates than is required on hand-fired locomotives. If practical, the grates should be shaken only when the locomotive is not using steam. When approaching grades the fire should be properly prepared by speeding up the stoker to meet the heavier demands. In the event of a clog which stops the stoker, and which cannot be quickly remedied, the fire should be maintained by hand until the obstruction is removed.

74. Duties of Fireman at End of Trip.—When approaching the terminal all the tank slides should be closed and the coal worked out of the conveyer and elevators. The throttle valve *6*, Fig. 5 (*a*), and the steam-jet line valve No. 3 should be closed tightly, but valves *4* and *5* should be allowed to remain set. It is also good practice to close valves *1* and *2*.

STOKER DISORDERS

75. Distributers Worn or Are Not the Proper Height.—If the distributers are worn or are not the proper height, the coal cannot be scattered evenly by regulating the jet pressure. The action of the steam in blowing the coal through the distributers causes the back end of the distributers to wear and become dished out. The steam jet, when it strikes the depression on the distributer, is thrown upwards and the coal will not be thrown far enough ahead in the firebox, but will bank near the door sheet. The distributer should be removed and the hole filled in or a new distributer applied.

If the distributers are allowed to hang too low, the coal will bank about 2 feet from the back sheet. On the other hand, if the distributers are too high, the coal will be carried in larger quantities to the front end of the firebox, and will

not be distributed, as it should be, over the back section of grates.

76. **Holes in Jet Nozzle Stopped Up.**—If any of the holes in the jet nozzles become stopped up with scale, the coal will be blown either toward the side sheets or the center of the firebox, depending on which holes are plugged. A plugged-up jet nozzle can be cleaned by disconnecting the union on the steam pipe below the jet, loosening the setscrew, and removing the nozzle. The holes can also be cleaned out sometimes by introducing a small wire into the peep hole in the elbow.

77. **Broken Pawls or Pawl Springs.**—A broken pawl in an elevator or conveyer drive and reverse is usually indicated by a knock in the casing. A broken spring usually causes a rattling, snapping sound in the casing. If both the pawls or springs break in an elevator casing, the casing and, therefore, the screw will either not turn at all or will turn irregularly whenever the broken or loose pawl happens to catch. Broken pawls and springs in the conveyer drive and reverse will affect the conveyer screw the same as an elevator screw.

78. **Operating Rod Will Not Stay in Central Position.**—If the operating lever *10*, Fig. 5 (*a*), will not stay in a central position, the catches *a* or the catch springs, Fig. 38, are broken or worn, or the groove a_2 in the operating valve stem is worn. The remedy is to wire the operating rod in position temporarily.

79. **Elevator Pawl Shifters or Reverse Lever Cannot Be Readily Moved to Reverse Position.**—If the elevator-pawl shifters or the reverse lever cannot be readily moved to reverse position, the steam pressure in the engine cylinder is probably holding the drive pawls tightly against the teeth of the ratchet wheels. The remedy is to reverse the steam piston with the operating rod.

80. **Engine Runs Slowly or Stops.**—The stoker engine will run slowly if the packing rings on the steam pis-

ton leak badly; if the piston packing is blowing, or if the engine is not receiving enough lubrication. The engine will stop if the reversing rod is bent, or the striking points worn, or if dirt is permitted to accumulate in the rack housing.

Leaky piston packing is indicated by the escape of steam at the drain pipe *p*, Fig. 5 (*a*), at the end of the gear-rack housing. This disorder will cause the engine to make a slow stroke when the conveyer and elevator screws are reversed. The dust that enters the gear-rack housing mixes with the oil and forms a hard deposit at the entrance housing. The dirt as it accumulates is pushed by the rack to the ends of the casing with the result that the rack is unable to complete the stroke. The remedy is to remove the cover from the gear-rack housing and to clean it out.

The exhaust pipe *x*, Fig. 5 (*b*), which leads from the engine to the smokebox, should be examined and cleaned out at regular intervals. If this pipe becomes plugged the engine will stop.

81. Tank Unit Fails.—If for any reason the part of the stoker on the tender should fail, the *engine can still be stoker fired* by raising the door in the deck over the transfer hopper and shoveling the coal into the hopper. Care should be taken not to feed large lumps.

CLOGS

82. Precautions to Be Observed.—Before trying to remove obstructions from, or doing any work on, the stoker, the steam should be shut off the stoker engine by closing valves *6* and *7*, Fig. 5 (*a*), in the steam line and the stoker piston should be returned to a dead position by lowering handle *10* on the operating rod to bottom position. This handle should be raised on the United States standard locomotives. The *hands should be kept out* of the stoker elevators and conveyers, and bars, rods, or levers should not be put in these parts until the precautions mentioned are observed. Care should also be taken *not to step in the stoker conveyer.*

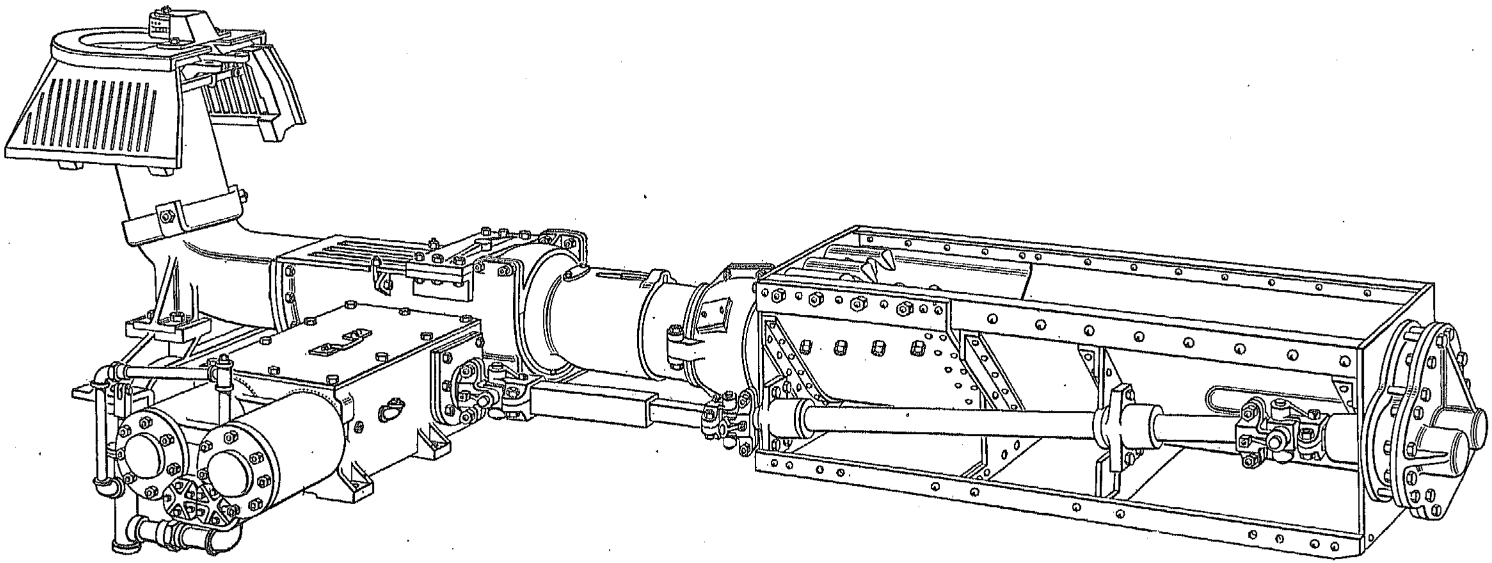
83. Locating Clogs.—The stoker may clog and stop because of iron, wood, slate, or other foreign matter in the coal; or the stoker may be stopped by a hard lump of coal, which can be broken up. Therefore, when the stoker stalls, the first thing to do is to open steam valve *7*, Fig. 5 (*a*). The opening of the valve increases the pressure in the engine and forces the obstruction through the crushing zone where it can be removed by opening the door in the transfer hopper. If the stoker has been stopped by a large lump of coal, the extra pressure will cause it to be crushed.

84. The trouble will have to be located if the stoker will not start with the increased pressure. To do so, the pressure to the engine should be shut off by closing valve *6*, Fig. 5 (*a*). The operating valve lever *10* should then be moved to its lowest position. This stalls the engine with the piston at the steam-head end of the cylinder. The reverse lever c_8 is next placed in center or neutral position, thus cutting out the conveyer screw. The operating valve *10* is then placed in center position and valve *6* is opened.

If the elevator screws work, the clog must be in the conveyer trough. If the elevator screws do not work, either one or both must be clogged because the conveyer screw is cut out in neutral position. The elevator screw which is clogged can be located by trying the pawl shifters b_4 and noting whether they can be raised to reverse position. If one of the shifters cannot be raised, the trouble will usually be found in that elevator because the screw, when it stops, will cause the pawls to wedge in the teeth of the ratchet wheel.

85. Removing Clogs.—If the elevators work, thereby indicating that the conveyer screw is clogged, the screw should be reversed as explained in Art. **62**, but it should not be run backwards for more than three revolutions. Steam valve *6* should then be closed before attempting to locate and remove the obstruction from the conveyer trough. Clogs in the conveyer trough usually occur in the crusher zone. In order to find the clog the coal should be shoveled out of the crusher. Clogs in the elevators usually occur at the bottom

of the elevator-casing doors and cause the obstruction to catch between the screws and the bottom of the door. An obstruction at this point can be removed by raising the transfer-hopper door in the deck. If the obstruction is in the elevator, the elevator screw should be reversed, as explained in Art. 64. If this will not remedy the trouble, the elevator-casing door should be removed and the obstruction taken out.



SB 507B 2505

Fig. 1

DUPONT SIMPLEX STOKERS

Serial 2505 Edition 1

MODIFIED TYPE B AND B-K STOKERS

DESCRIPTION AND OPERATION

1. **Views of Stoker.**—An exterior view of the modified type B Simplex stoker, manufactured by the Standard Stoker Company, Inc., is shown in Fig. 1. In Fig. 2 the stoker is shown in position on the locomotive with the side of the locomotive and some of the stoker parts broken away, and in Fig. 3 the stoker is shown with its parts assembled.

2. **Names of Parts.**—The names of the principal parts of the modified type B stoker, Fig. 3, are as follows: *a*, stoker engine; *b*, intermediate drive shaft (driving section); *c*, intermediate drive shaft (driven section); *d*, rear drive shaft, equipped with bearings *e* for attachment to tender trough; *f*, main-drive pinion and shaft, made in one piece; *g*, main-drive gear, mounted on the shaft shown; *h*, main-drive gear housing; *i*, main-drive gear-housing cover; *j*, tender conveyer screw; *k*, intermediate conveyer screw; *l*, front conveyer screw; *m*, tender trough; *n*, inside rear bowl; *o*, outside rear bowl, made in halves; *p*, intermediate conveyer shell (rear half); *q*, intermediate conveyer shell (front half); *r*, front conveyer trough; *s*, front elbow; *t*, upper vertical housing; *u*, protecting grate; *v*, distributor jet connected by five pipes to the distributor jet manifold *w*. The conveyer screws *j*, *k*, and *l* are connected by universal joints.

3. **Arrangement of the Parts.**—The stoker engine, Fig. 3, is secured to a bracket that is bolted to the frame of the locomotive. In cases where the weight carried on the trailing truck is

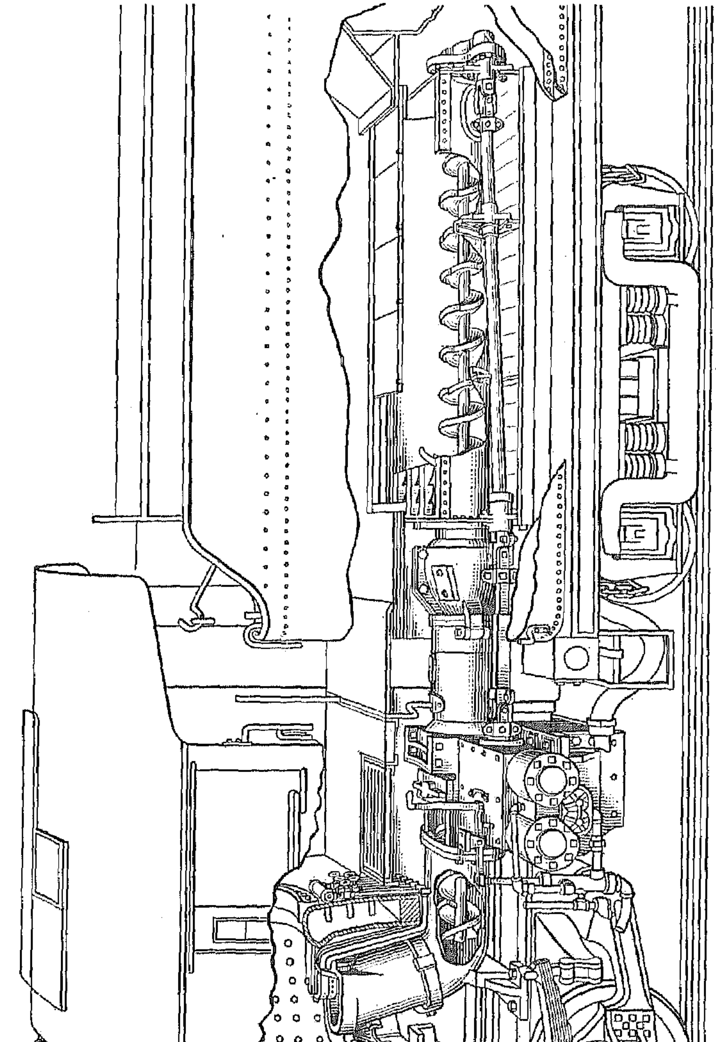


Fig. 2

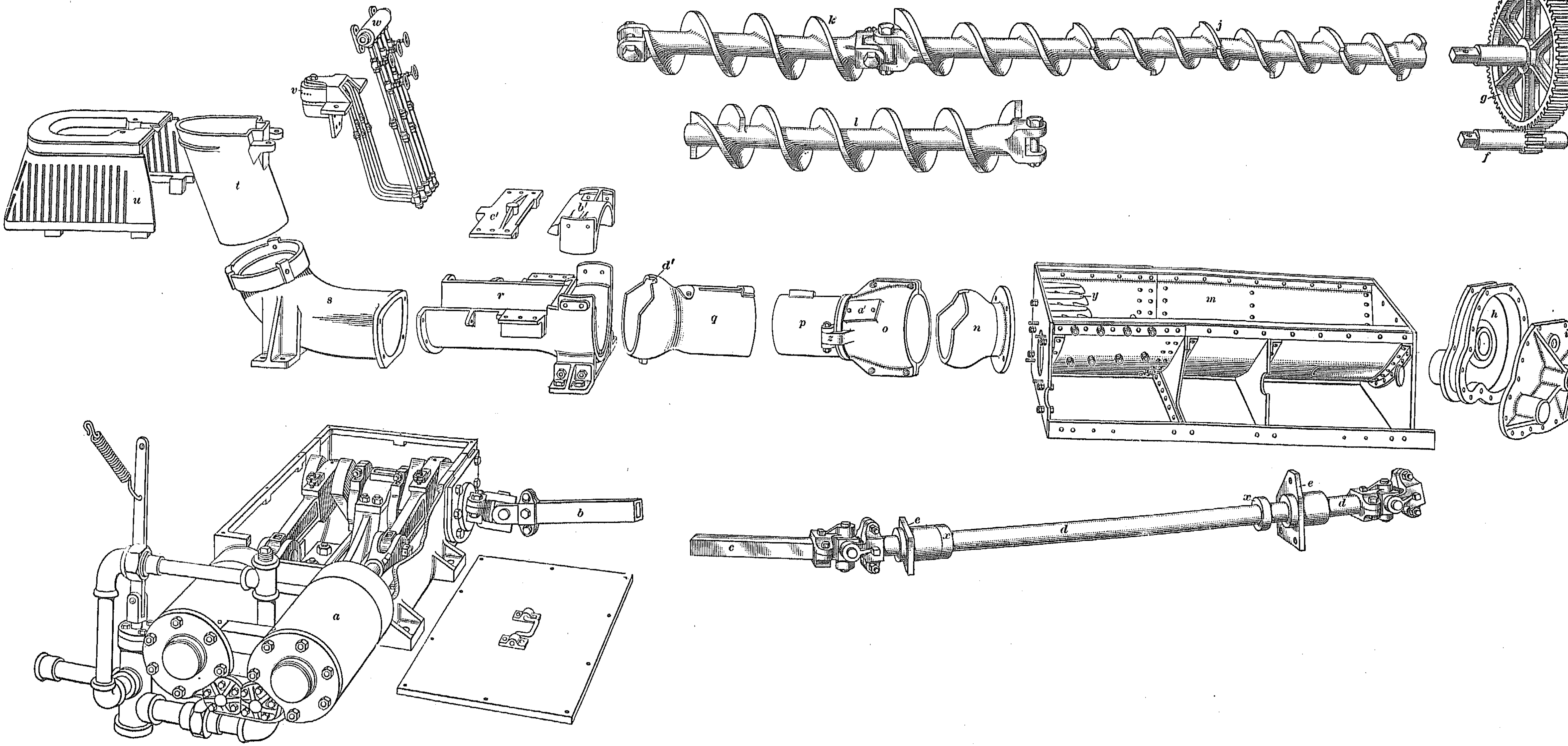


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Fig. 3

near the permissible limit the stoker engine is carried on the left front corner of the tender. This application dispenses with the intermediate drive shaft but requires a flexible steam pipe to connect the stoker engine with the locomotive.

The crankshaft of the stoker engine is connected to the driving section of the intermediate drive shaft by a universal joint. This joint in combination with the universal joint between the driven

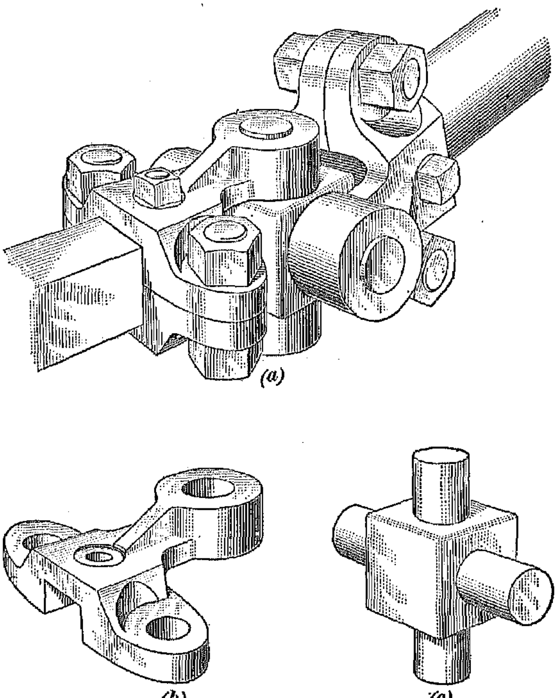


Fig. 4

section of the intermediate drive shaft and the rear drive shaft prevents the uneven movement of the engine and tender with respect to each other, from setting up strains in the shafts. The universal joint is shown assembled in Fig. 4 (*a*); it is made up of four clips and one block as shown in (*b*) and (*c*). The square end of the driven section of the shaft has a sliding fit in the end of the driving section. This arrangement allows for the varia-

tion in the distance that takes place between the engine and the tender when running on the road.

4. Bearings *e*, Fig. 3, that contain bushings are bolted to the cross-members of the tender trough; they serve to carry the rear shaft *d*, and the collars *x* serve to prevent any back-and-forth movement of the shaft when the stoker is working. The rear drive shaft extends through the rear bearing as shown; a universal joint connects the back end of the shaft to the drive

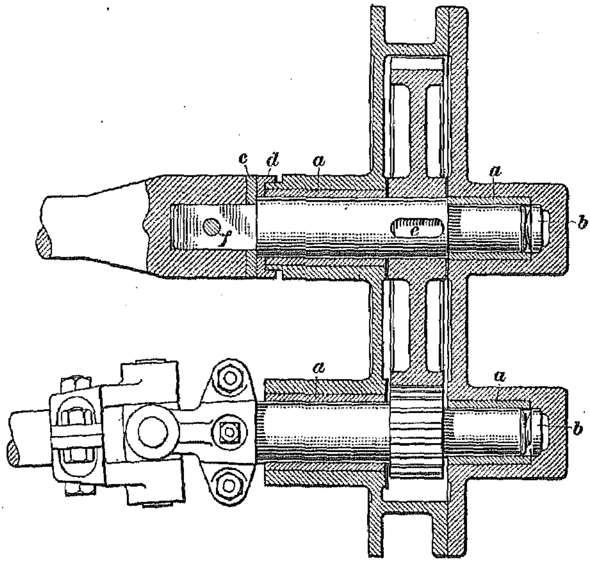


FIG. 5

pinion shaft *f*. A gear housing *h* with a cover *i* that contains a grease plug is bolted to the rear end of the tender trough; this housing and cover serve to enclose the main-drive gear and the pinion gear and also provide bearings for the gear shafts. These bearings are shown at *a* in the detail in Fig. 5. This illustration also shows the thrust buttons *b* provided to absorb the wear due to the backward thrust imposed on the shafts with the conveyer screws moving the coal forwards toward the engine.

The thrust on the thrust button of the main-drive shaft is relieved by a manganese thrust washer *c*, spot-welded to the

extreme rear end of the tender screw; the washer bears against a manganese thrust washer *d* on the main-drive gear-housing bearing. A key *e* holds the main-drive gear to its shaft; the left end of this shaft, which is square, fits into the end of the tender conveyer screw and is secured to it by a $\frac{5}{8}$-inch bolt *f*. This bolt prevents the screw from slipping forwards when the stoker is reversed, the tendency being for the screw to move ahead for this direction of rotation.

The conveyer screws are connected by universal joints, each made up of a block and two pins as shown at the joint between the tender conveyer screw and the intermediate conveyer screw; at the other joint the pins alone are shown. The double flight on the forward end of the front conveyer screw is designed to give a continuous movement to the coal. If but a single flight were used, the forward and upward movement of the column of coal in the vertical housing would be intermittent and would result in a packing of the coal in the elbow and the stalling of the stoker as this intermittent movement would be equivalent to a tamping action from the bottom. By introducing the double flight the movement of the coal is not interrupted, as the second flight continues the movement where the first flight leaves off. Then, on a further rotation the first flight again picks up the movement where the second flight left off.

5. The tender trough, Fig. 2, is attached rigidly to the tender frame, the top of the trough coming flush with and taking up a portion of the area of the tender floor. An arrangement of slides is provided to close the top of the trough when taking coal; with the stoker in operation the slides are slid forwards one at a time according as the coal supply on the tender diminishes. Thus, when all the coal possible falls into the tender trough with the first slide moved forwards as shown, the next slide is moved ahead to insure a further supply.

The main crusher plate *y*, Fig. 3, is bolted to the front end of the tender trough and the lumps of coal are crushed by being forced against the projecting spikes by the conveyer screw. An auxiliary crusher plate with inwardly projecting prongs is secured to the left side of the trough and assists in breaking

down the large lumps. In order to take care of the greater wear on the tender conveyer screw in the crushing zone, the first two flights of the screw are increased in thickness.

6. The inside rear bowl *n*, Fig. 3, is bolted to the outside of the front end of the tender trough, the outside rear bowl *o* is hinged to the intermediate conveyer shell *p* and is made in halves that, when bolted together, enclose the inside bowl. This arrangement forms a ball-and-socket joint that provides the necessary flexibility when the tender moves independently of the engine. The upper half of the inside rear bowl is cut away, as shown to permit work to be done on the universal joint within after the halves of the outside rear bowl have been separated and swung to one side on their hinges *z*. The lower half of the inside bowl is extended farther into the outside bowl than the upper half so as to prevent leakage of coal. Foreign matter that clogs the stoker can be removed by taking off the covers *a'*, one on each side. The rear intermediate conveyer shell telescopes into the shell in front; the rear shell is prevented from revolving and thereby turning its covers out of their proper position by a raised rib that fits into a slot in the front half. Unless the rear shell is maintained in the position shown, it would be difficult or impossible to remove the covers in the event of clogs. The spherical-shaped end of the front intermediate conveyer shell rests within a similar shaped opening in the end of the front conveyer trough and is retained there by the bowl cover *b'* bolted to the trough. Forward of the bowl cover, the top of the conveyer trough is closed by the cap *c'*. The purpose of this cap, as well as the hole *d'*, normally closed by a cap, is to permit the removal of foreign matter that clogs the conveyer screw. A coverplate slotted so that the speed of the stoker as well as the amount of coal that is passing can be observed, closes the trough forward of the cap *c'*. The front elbow is carried on a support that is bolted to the frames of the locomotive. At the rear, the elbow is bolted to the conveyer trough; the vertical housing fits into and rests on a flange in the front end of the elbow. Housing bolts, screwed through the elbow, retain the vertical housing in position.

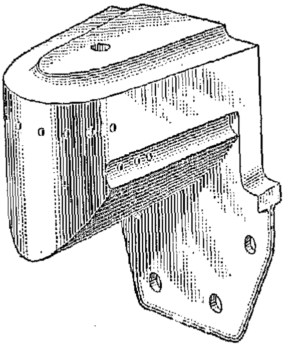


Fig. 6

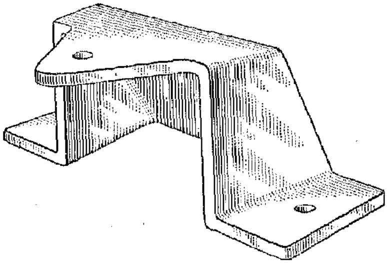


Fig. 7

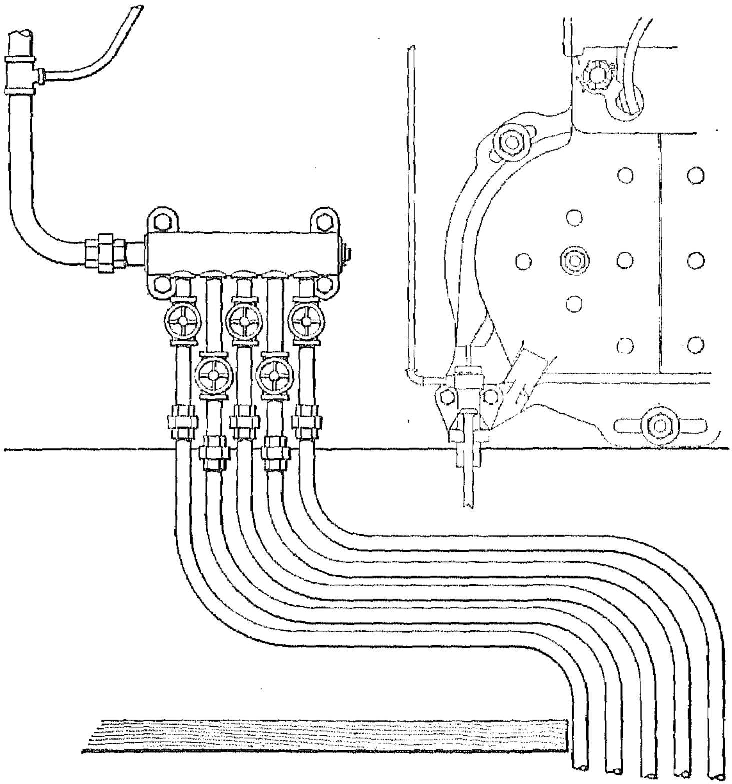
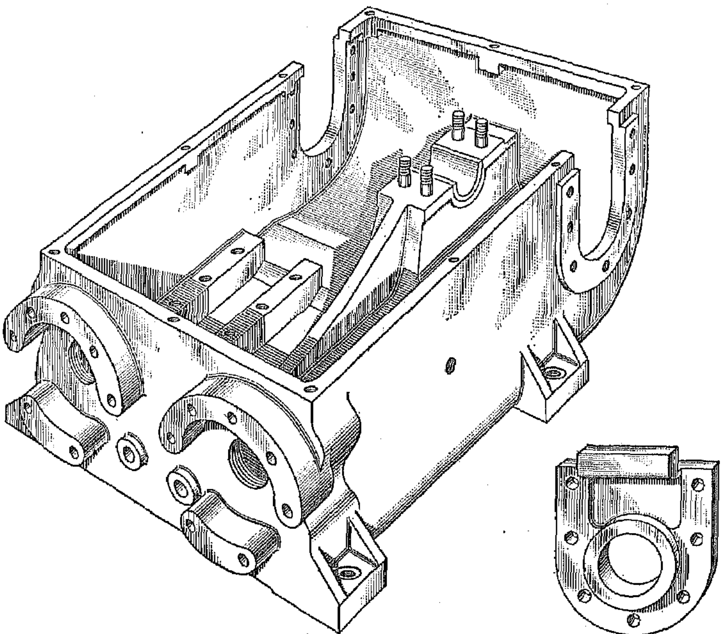


Fig. 8

7. The vertical housing extends up into the firebox just forward of the back sheet, an opening being made in the grates for this purpose. A protecting grate encloses the greater part of the vertical housing so as to protect it from the heat of the firebox. The grate is prevented from overheating by an arrangement of slots through which the air is drawn from the ashpan



(a) (b)

Fig. 9

by the draft. A firing table is mounted on top of the protecting grate; this table comes about level with the top of the vertical housing.

A distributor jet, Fig. 6, is bolted to the rear of the top of the vertical housing, and is covered on the top by a hood, Fig. 7. The distributor jet, the purpose of which is to blow into the firebox the coal as it emerges from the vertical housing, has a series of fourteen holes drilled in groups of twos and threes. The steam from one group of three holes distributes the coal to one of the back corners of the firebox, another group of three

holes serves one side of the firebox, and a group of two holes serves the center of the firebox. Two groups of three holes each on the other side of the jet are used for the opposite back corner and side of the firebox. As there are five groups of holes, four groups of three holes and one group of two holes, five steam pipes are required to convey the steam from the mani-

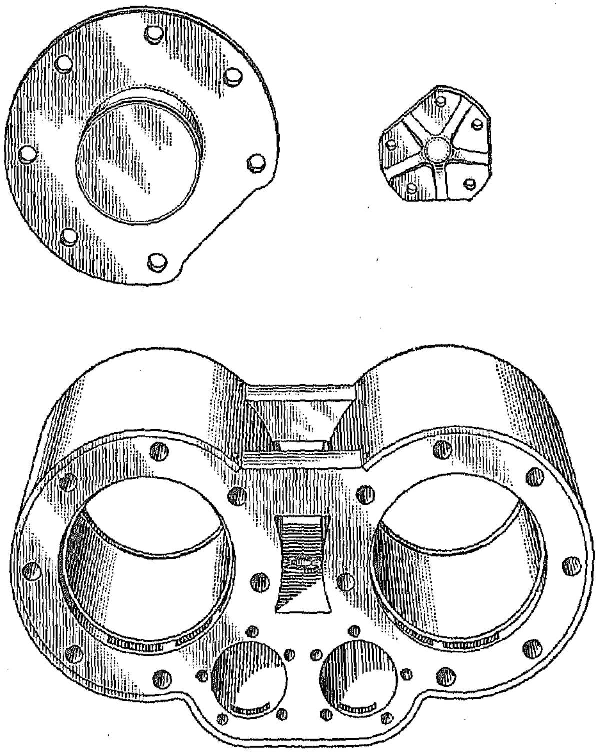


FIG. 10

fold *w*, Fig. 3, to the distributor jet. Each pipe has a steam valve, Fig. 8, in which the two outside valves control the steam supply to the group of holes that serves the back corners of the firebox. The center valve performs a similar function for the center of the firebox, and the other two valves regulate the steam to the two groups of holes that serve the sides of the firebox.

THE STOKER ENGINE

8. Description.—The engine bed of the stoker engine is shown in Fig. 9 (*a*) and the cylinders that bolt to the front end of the bed are shown in Fig. 10. The moving parts of the engine are given in Fig. 11. The ends of the crankshaft *a* are carried in suitable bearings, Fig. 9 (*b*), that are bolted to the outside of the engine bed; the middle portion of the shaft turns in the bearing shown in the bed.

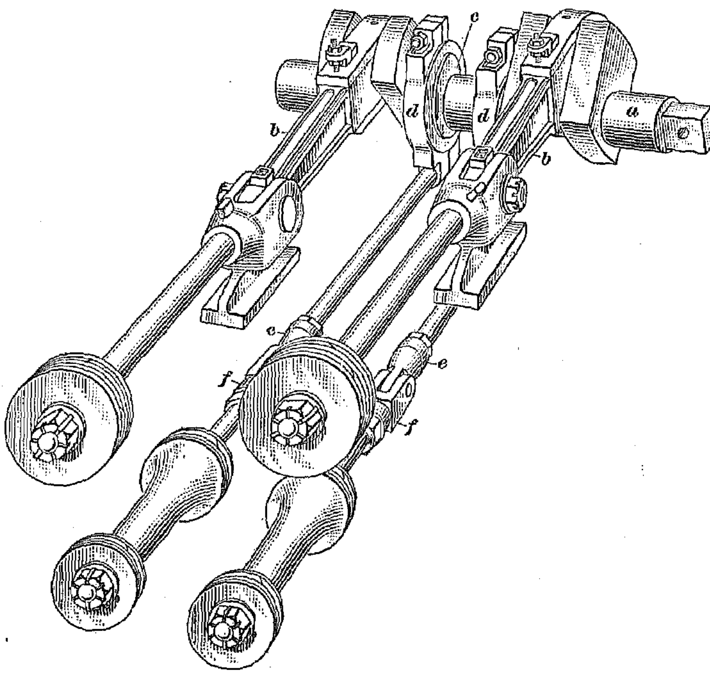


Fig. 11

The connecting rods *b*, Fig. 11, are secured by straps to the cranks on the shaft; the arrangement for connecting the strap to the rod as well as for holding the brasses in the strap is shown disassembled in Fig. 12 and assembled in Fig. 13. With the brasses assembled in the strap the slots in the strap are lined up with the slot in the rod, the key is then applied, and next the

wedge. The faces of the key and the wedge in contact are oppositely tapered so that when the nut on the key keeper *a* is turned down, the complete arrangement is held firmly together.

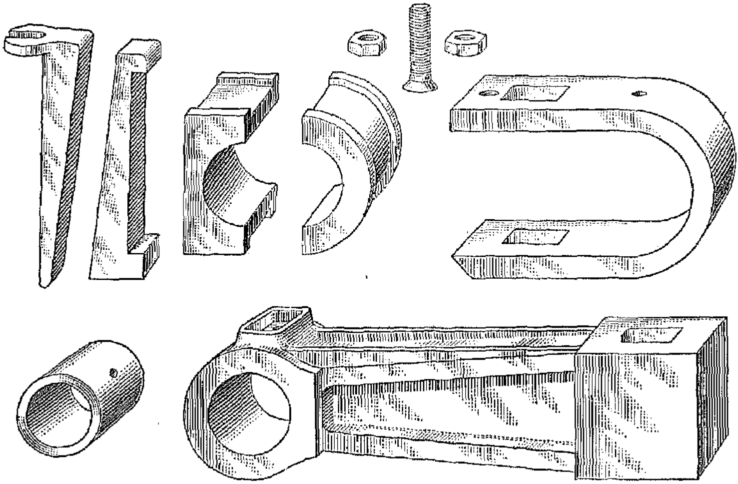


FIG. 12

It will be noted that the key keeper is screwed through the strap and welded over.

9. At the front end, each connecting rod is secured to its crosshead by a wristpin; a key is used to hold each piston rod

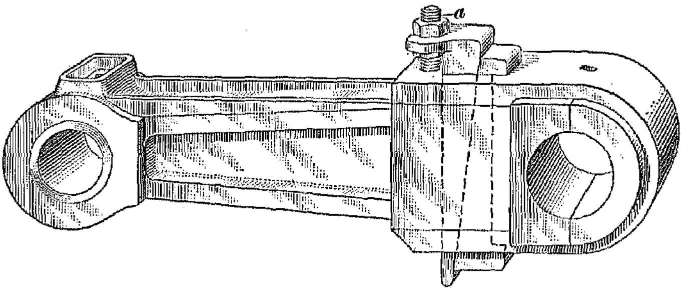
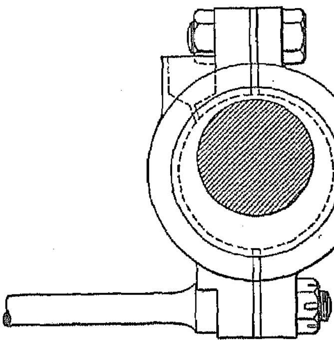
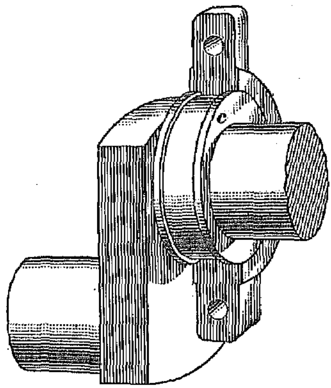


FIG. 13

in its crosshead. The eccentrics *c*, Fig. 11, are forged integral with the crankshaft. At the top the halves of each eccentric strap *d* are secured together on its eccentric by a bolt; at the bottom the eccentric rod as shown by the detail in Fig. 14 (*a*)

serves to hold the strap together. A view of one half of an eccentric strap on its eccentric is shown in (*b*). As the eccentric rods have an up-and-down as well as a to-and-fro movement, flexible joints must be provided at their front ends. Each joint comprises an eccentric rod coupling *e*, Fig. 11, and a valve-stem coupling *f*, connected together by a pin. Locknuts are provided, as shown, to prevent the couplings that are screwed on to the rods from working loose.


(*a*)



(*b*)

Fig. 14

The valves used with the stoker engine have no lap, that is, the steam ring on the valve is the same width as its steam port. With valves of this kind, the steam passes to the cylinders for the entire stroke of the pistons.

The moving parts of the engine within the engine bed are lubricated by the splash system. A cover seals the top of the engine bed and the oil is kept to a height indicated by a petcock in the side of the bed.

10. Reversing Arrangement.—It is possible to reverse an engine the valves of which have no steam lap, by converting the steam passage into an exhaust passage and the exhaust passage into a steam passage. Thus, in Fig. 15, steam enters the steam chest through the passage indicated and exhausts from the cylinders through the passage marked *exhaust*. With the valve in the position shown the piston will move in the direction of the

arrow. Should the exhaust passage be now closed to the atmosphere and converted into a steam passage and should the previous steam passage be closed to steam and connected to the atmosphere, then the piston will move in the opposite direction; that is, the steam will enter the cylinder through the port *a*, and the port *b* will be connected to the atmosphere. The procedure just explained is the same as if the valve were changed from inside to outside admission, hence changing a valve without

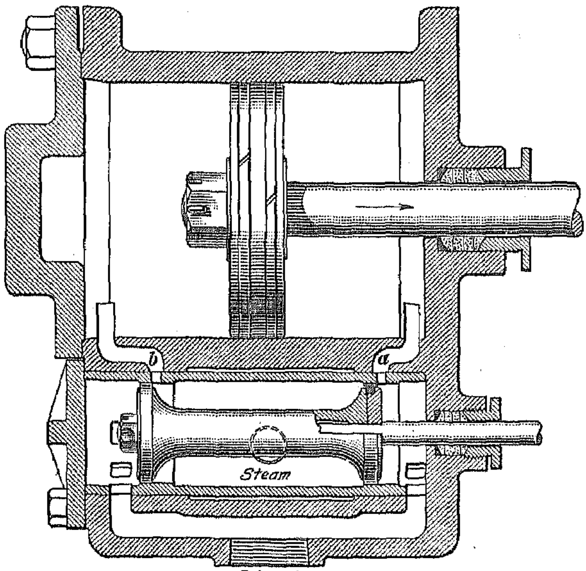


FIG. 15

steam lap from an inside admission type to one of an outside admission type will reverse the engine.

11. An exterior view of the reversing valve and the piping used to reverse the functions of the steam and exhaust passages of the stoker engine are shown in Fig. 16. The steam pipe and the exhaust pipe under normal operating conditions are lettered accordingly; the steam pipe to the boiler is also indicated.

The position of the reversing valve when the stoker is conveying coal to the firebox is shown in Fig. 17 (*a*). With the valve *b* pulled all the way up by its valve handle as shown, live

steam from the boiler passes around the central portion of the valve to the steam chests and cylinders. The exhaust steam from the cylinders passes by the end of the valve to the atmosphere. When it is desired to reverse the engine, the valve is pushed all the way down as in (*b*). The live steam is now compelled to pass to the pipe that in normal operation was used for an exhaust pipe; also, the steam exhausts through the pipe that before was used as a steam pipe, thence through the hollow valve to the atmosphere. The interchanging of the functions of the steam and exhaust pipes as already explained causes the motion

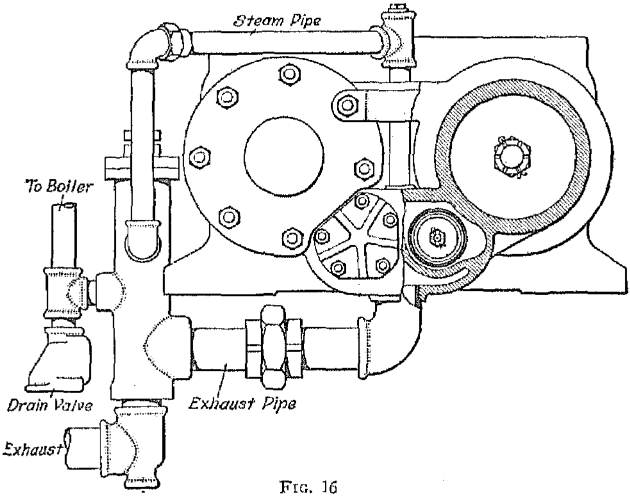


FIG. 16

of the engine to be reversed. The stoker engine can be stopped by the reversing valve by placing it in neutral position or midway between normal and reverse positions. In neutral position, the upper end of the valve prevents the steam from the boiler from passing to the steam pipe that leads to the steam chests of the stoker engine.

CAB PIPING

12. Arrangement of Piping.—A typical cab piping arrangement is shown in Fig. 18. The steam piping to the jet manifold comprises a section of three-quarter inch pipe; the jet valve in this pipe controls the pressure for blowing the coal from the firing plate into the firebox. A three-quarter inch globe valve

is located in the pipe near to the steam turret. Five one-half inch steam pipes lead from the jet manifold to the distributor jet. The valves in these pipes are used to distribute the coal to the various sections of the firebox in accordance with the manner in which the engine is burning the fire. A one-inch

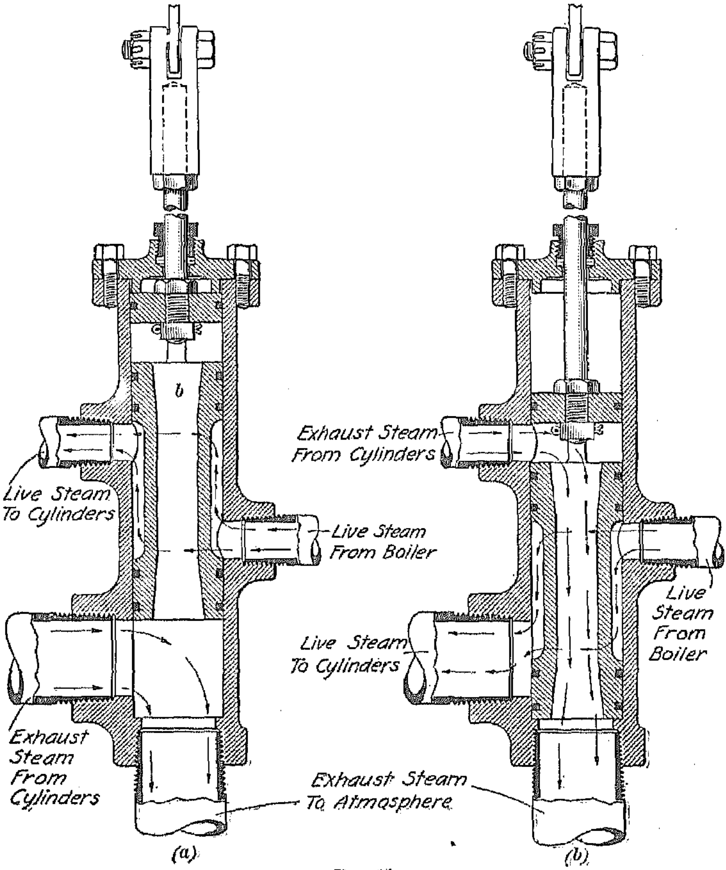


FIG. 17

steam pipe in which is placed a one-inch globe valve and a one-inch booster valve leads from the steam turret to the reversing valve of the stoker engine. Under normal working conditions the booster valve is closed; the steam then by-passes from the one-inch pipe, through the section of one-half inch pipe shown,

to the stoker engine. The throttle valve for the normal operation of the stoker is located in this latter pipe; the booster valve is used only when reversing the stoker to remove clogs or when

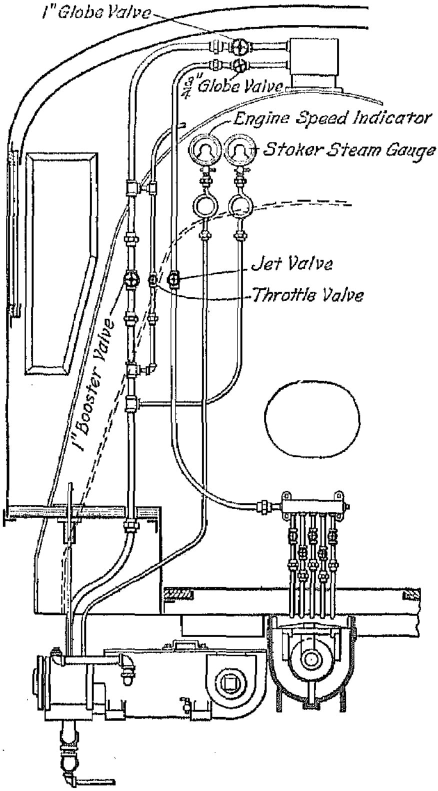


Fig. 18

additional power is required to crush a large lump of coal. Two gauges, one to indicate the speed of the stoker engine, and the other, the steam pressure, are piped as shown.

LUBRICATION OF STOKER

13. Lubrication of Stoker Engine.—The lubricator feed for the cylinders of the stoker engine should be set to feed from two to three drops per minute. The splash system is used to lubricate the moving parts in the engine bed. Car oil is used

and it is applied through the one-inch oil filler pipe shown in Fig. 19. The oil should be carried in the bed at a depth of

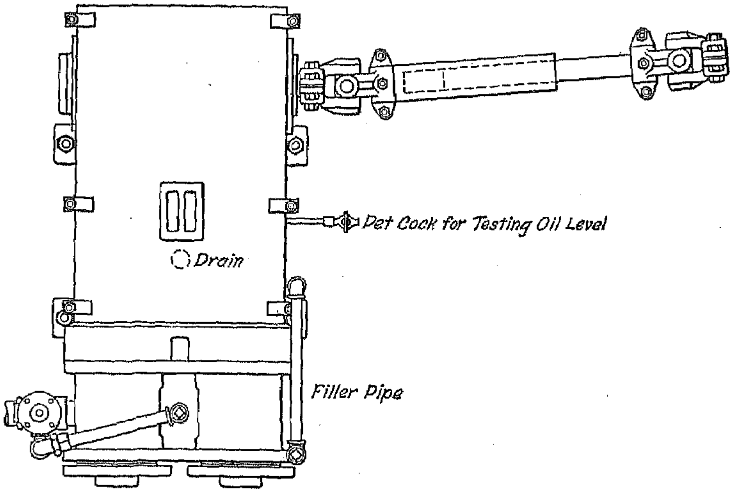


FIG. 19

$1\frac{1}{2}$ inches at all times; the $\frac{3}{8}$-inch petcock shown should be used frequently to test the height of the oil. The oil should be drained

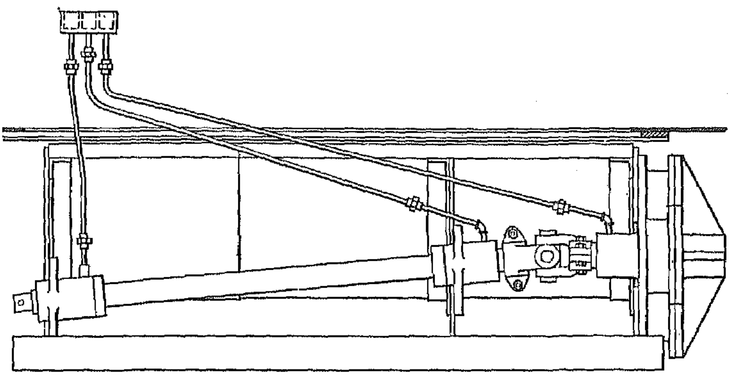


FIG. 20

out through the oil drain in the bottom of the bed after the locomotive has made 15,000 miles. The slip joint in the drive shaft as well as the universal joints should be oiled daily.

14. Lubricating Tender Unit.—The housing that encloses the main drive and pinion gears is packed with grease through a filling plug in the cover. A thorough inspection of the gear housing should be made every 30 days and additional gear grease supplied if necessary. A drain plug is provided in the housing to be used when the case is cleaned out.

The two bearings of the rear drive shaft and the front bearing of the main-drive pinion shaft are lubricated with car oil through three pipes, Fig. 20, each of which is connected to its compartment in an oil box. The rear pipe carries the oil to the front bearing of the main-drive pinion shaft, the pipe next to it is used to lubricate the back bearing of the rear drive shaft, and the other pipe serves to lubricate the front bearing of this shaft. A small quantity of oil should be poured into each compartment at the beginning of each trip.

OPERATION

15. Starting the Stoker.—Before starting the stoker, ascertain by opening the petcock whether the oil in the engine bed is of the correct height, then start the stoker lubricator. Next, open all the valves in the steam pipes that lead from the manifold to the distributor jet, then open the jet valve slightly, thereby clearing the pipes and the jet of any condensation. Do not open the jet valve fully and suddenly, because this might crack the distributor. To start the stoker engine, first open the throttle valve slowly to permit condensation to escape through the automatic drain valve before the engine operates at speed; the drain valve closes when the condensation all escapes. Then, with the handle of the reversing valve in operating position, open the throttle enough to run the stoker at the required speed. To start the coal feeding, next pull the first tender slide forwards, the coal will now fall into the conveyer and pass to the firebox. The amount of coal passing as well as the speed of the stoker can be observed through the slotted coverplate of the front conveyer trough. When the coal begins to overflow the protecting grate, adjust the distributor steam to obtain an even distribution.

16. Stopping the Stoker.—Shortly before reaching the terminal, close the trough slides and allow the stoker to run

until the conveyer is empty. Arriving at the terminal with an empty conveyer permits the roundhouse staff to make the proper inspection; also, it prevents the freezing of wet coal in winter. Reverse the stoker a few revolutions so as to back the coal down in the vertical conduit and place the operating lever in neutral position. Next, close the stoker throttle valve, but leave the jet valve and the valves to the distributor jet open slightly. These valves are closed after the fire has been knocked out; leaving them open prior to this prevents the coal on top of the conduit from catching fire. Operate the distributor valves in the same way when lying on sidings, when drifting down long grades, etc.

17. Removing Obstructions.—The fact that the stoker has stopped will be indicated by the speed-indicator gauge and by the pointer on the steam gage. In normal operation, the hand of the speed-indicator gauge will vibrate between the 15 and the 25 marks; when the stoker stops, the hand of the steam gauge will rise to nearly boiler pressure. The pressure will drop back to normal again as soon as the stoker starts.

The stopping of the stoker will be found to be due in nearly all cases to some foreign matter in the crusher; ordinarily an obstruction never gets farther than this point. Try to release the obstruction by reversing the stoker, then open the booster valve. If the obstruction is slate, sulphur balls, etc., it can be crushed by one or two reversals of the engine; but do not allow the conveyer screw to run in reverse more than three revolutions. Once the obstruction is by the crusher, it is almost certain to pass through the remainder of the conveying system without further trouble. If the stoker reverses and stops again after the reversing-valve handle is returned to normal position the indications are that the obstruction is a piece of iron too large for the crusher to handle. In this event, remove the coal above the crusher and take out or pry out the obstruction with a bar. If necessary, the crusher can be taken out by removing the two bolts that fasten it to the front-support plate of the tender trough.

Before attempting to remove a foreign substance from the conveyer system be sure that the throttle valve and the booster

valve are closed tight, also that the reversing valve is in neutral position.

18. **Stoker Firing.**—When taking charge of the engine, build up the fire by hand and do not start stoker firing until after leaving the yard with the train. A good job of firing implies that the coal is supplied to the firebox in accordance with the way the engine is being worked, and also distributed where needed. As light a fire as possible should be carried at all times. The amount of coal that is being conveyed to the firebox is governed by the speed of the stoker engine, which can be varied, as occasion requires, by the throttle valve. The steam pressure for blowing the coal into the firebox is governed by the jet valve, which should be opened about one-half turn or until the gauge shows about 40 pounds. When the locomotive is working light, this valve need not be opened so wide; also the throttle valve must be closed somewhat to reduce the stoker speed. When working heavy, the jet valve must be opened wider because the draft retards the carrying of the coal forwards. Also the throttle valve should be opened wider. The distribution of coal to the various parts of the firebox in accordance with the way the engine is burning the fire is governed by the five distributor valves. The valves should be opened about one-quarter turn when starting out, then if the draft is not causing the fire to burn evenly, their opening should be regulated accordingly. If the engine is burning the fire evenly, the stoker can be run with good results by operating the throttle valve and the jet valve.

Successful stoker firing, then, largely means the proper operation of the steam valves to meet the variable conditions of service and of draft.

MAINTENANCE

19. **Packing Piston and Valve Stems.**—Both the piston and valve stems have two packing glands; soft packing is used on the engine case to prevent the loss of oil, and semi-metallic packing is used on the cylinders to prevent the escape of steam. The piston-rod stuffingboxes have to be packed from the engine bed, but the valve-stem stuffingboxes, being readily accessible, can be packed in the usual manner.

To pack the piston rod, proceed as follows: First turn the stoker engine so that the crosshead connected to the piston rod to be packed is at the back end of the stroke, then with a spanner wrench provided for the purpose, screw the entire gland *a*, Fig. 21, out of the engine bed and slide it back on the rod. Next, slide the gland *b* back through the opening in the engine bed and apply the packing to the piston-rod stuffingbox, then slide the gland *b* back and screw the gland *a* in firmly. The engine-case packing in the gland *a* is kept tight by the gland *c*.

20. Renewing Valve Rings.—To renew the ring on a valve proceed as follows: First, before disconnecting the valve stem, set a pair of dividers to the marks on the valve stem and valve

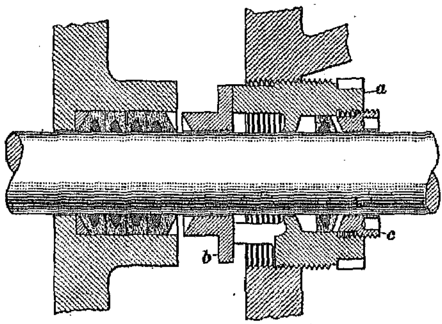


FIG. 21

rod. Then slack off the valve-stem locknut, screw the stem out of the clevis and pull the valve out of the steam chest. Separate the valve by taking off the front nut, renew the ring and put the valve together again. When replacing the valve, see that the points of the dividers drop into the marks to which they were previously set; otherwise the valves will be out of adjustment.

21. Setting the Valves.—To set the valves, first place the crank of the right engine on the front dead center. This crank is on the right-hand side when facing the engine. The right valve should now measure 1$\frac{43}{64}$ inches from the outside edge of the right valve bushing to the valve packing ring; at the left valve the measurement should be 2$\frac{3}{32}$ inches.

22. Disconnecting Engine From Tender.—To disconnect the engine from the tender remove the bolt in the universal joint between the front conveyer screw and the intermediate conveyer screw. The joint can be reached by removing the bowl cover *b′*, Fig. 3. The vertical elbow and the front trough must be empty before recoupling; otherwise, damage will result by the screw pushing coal ahead of it, as the engine and tender are moved together. To remove the intermediate conveyer screw, open up the outside tender bowl and disconnect the universal joint. To remove the tender conveyer screw, drive out the bolt that connects the end of the screw to the square end of the main-drive shaft.

TYPE B-K STOKER

23. Description.—An exterior view of the type B-K stoker manufactured by the Standard Stoker Co., Inc., is shown in Fig. 22. A sectional view of the conveyer system is given in Fig. 23. This type of stoker was designed for use on existing hand-fired locomotives the construction of which did not permit of the application of the stokers in general use, but its capacity is such as to meet the requirements of the largest modern locomotive. As with the type B stoker, the stoker engine can be placed on the tender, thereby reducing the weight on the trailing truck. Only two conveyer screws are used, the tender conveyer screw *a* and the front conveyer screw *b*, which are connected by a universal joint. This joint as well as the ball-and-socket joint surrounding it are similar to those already described. The front conveyer screw is enclosed within the back conveyer trough *c* and the front conveyer trough *d*; these troughs telescope as shown. Connected to the front conveyer trough by a ball-and-socket joint is a discharge box *e*, which at the front is bolted to the back sheet of the firebox. The height of the discharge box is such as to bring its top in line with the lower level of the firedoor opening, hence the opening is cut down to accommodate the area of the front of the box. This arrangement does not interfere with the action of the firebox door, which can be operated in the usual manner when necessary. A distributing plate *f* on which the coal drops from the discharge box is located

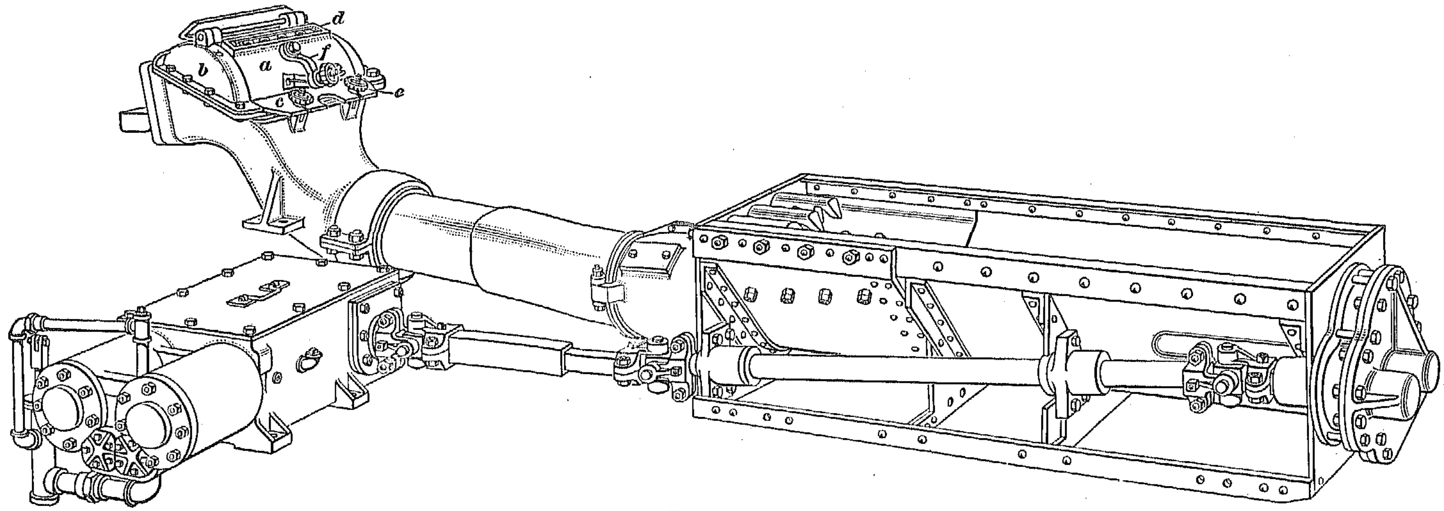


Fig. 22

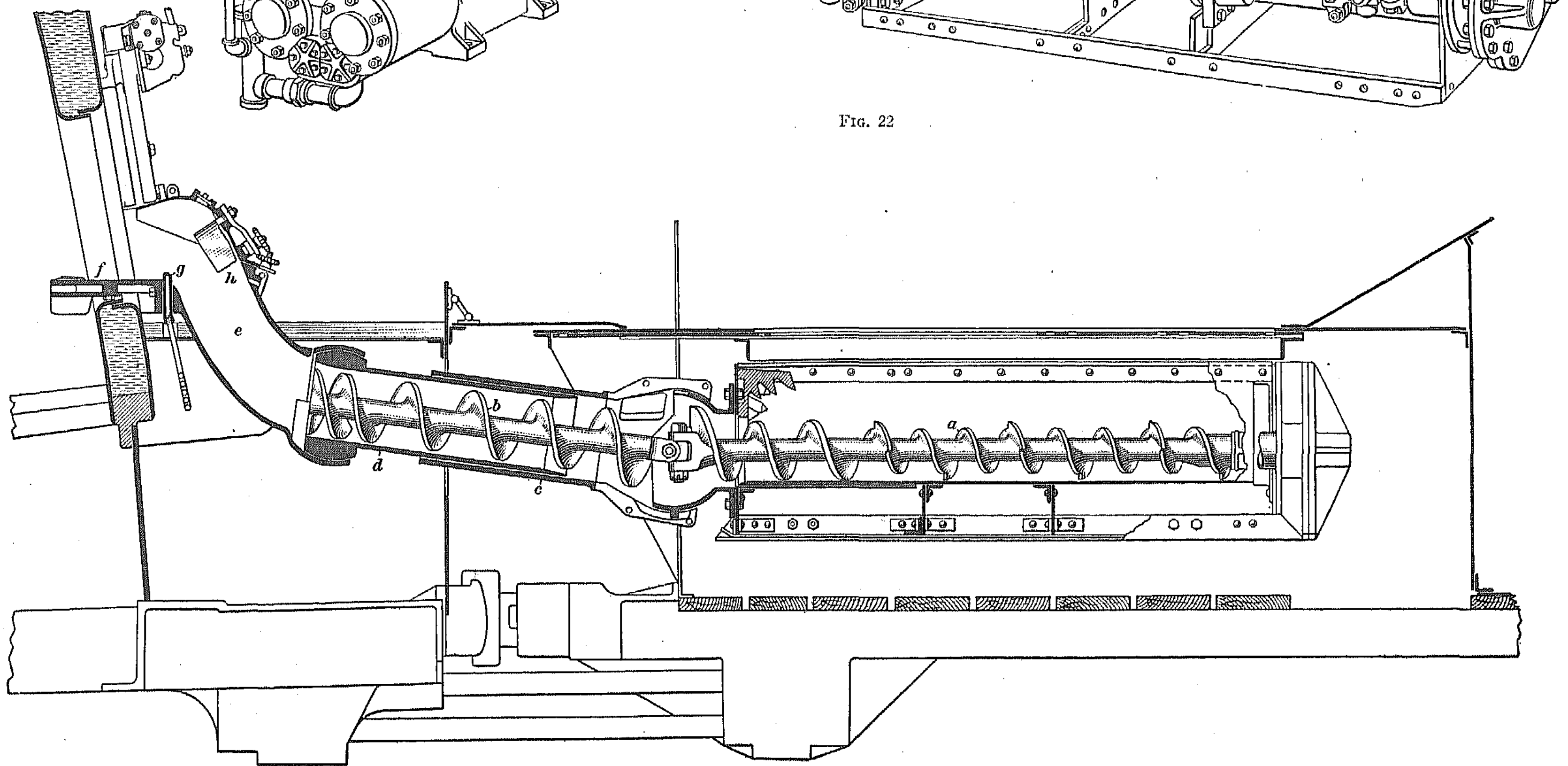


Fig. 23

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in the bottom of the opening as shown; the coal is blown off the plate by the steam from the steam jet *g*. A manifold is connected to the steam jet by means of five pipes as with the type B stoker. Grooves are provided at the front of the distributing plate so as to deflect the required amount of coal into the back corners of the firebox. Except as noted in the foregoing the type B-K stoker is similar to the type B.

24. As shown in the detail of the upper portion of the discharge box, Fig. 22, the outside cover *a* is hinged to the inside cover *b*, which in turn is bolted to the top of the box. The outside cover, the purpose of which is to permit access to the upper end of the discharge box, is held closed by two nuts *c* screwed to eyebolts. A series of holes in the top cover are closed by a slide *d*; these holes permit the operation of the distributing system to be observed, also air can be admitted through them if desired. The deflector plate *h*, Fig. 23, operated by a handle *f*, Fig. 22, on the outside of the box is used to deflect more of the coal to one side of the firebox than to the other, if the draft conditions require uneven distribution.

25. Removing Conveyor Screws.—To remove the front conveyer screw, disconnect the locomotive from the tender, open up the ball clamp at the tender bowl by removing the four $\frac{1}{2}$-inch bolts on the connecting flange, and swing the bowl open on its hinges. Then remove the bolt from the universal joint.

To remove the tender screw, knock out the bolts that hold the screw to the square end of the main-drive shaft.